Seismicity and Surface Deformation of Mauna Loa Volcano, Hawaii

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Changing patterns of seismicity and surface deformation indicate that magma is being injected and stored in a shallow reservoir beneath the summit, and that the probability of an eruption is increased.

Introduction

Mauna Loa is a 4169-m-high shield volcano on the Island of Hawaii. Its latest two eruptions occurred on the southwest flank in 1950 [*Macdonald*, 1954] and, mainly within the summit caldera, in 1975 [*Lockwood et al.*, 1976]. The oval summit caldera is 3 by 5 km in diameter, with cliffs as much as 180 m high (Figure 1). It is elongate in the direction of two principal rift zones that extend northeastward and southwestward from the summit. These rift zones, which are commonly vents for flank eruptions, form the gently sloping ridges that give Mauna Loa its Hawaiian name—Long Mountain.

Flows beheaded by the caldera have been radiocarbon dated as young as 590 ± 70 years, which is therefore the maximum age for the latest episode of major caldera collapse on Mauna Loa. The caldera was 120 m deeper in 1841 than at present [*Macdonald*, 1971], but it is now filled to the point where voluminous summit flows spill out from its low south end.

Increased seismicity beneath Mauna Loa precedes at least some eruptions [*Finch*, 1943; *Koyanagi et al.*, 1975]. In addition, surface deformation, as expressed by widening of the caldera, was detected by electronic-distance-measurement (EDM) survey lines during the year before the 1975 eruption. Both the distribution of earthquake hypocenters beneath Mauna Loa and the pattern of surface deformation are important evidence for interpreting the presence, size, and depth of shallow magma reservoirs beneath Mauna Loa.

The data presented in this report come from the combined efforts of the entire staff of the Hawaiian Volcano Observatory from 1962 to the present.

Seismicity

Figures 2 through 6 plot the distribution of earthquakes in time and space beneath the summit region of Mauna Loa. The earthquake locations have been obtained from an increasingly sophisticated network of seismic stations that now number 47 on the Island of Hawaii. To eliminate any bias from the increased number and better distribution of seismometers, only earthquakes of magnitude equal to or larger than 2.0 with horizontal and vertical location uncertainties of less than 2 km are plotted in Figures 2 to 5. The location limit of the present seismometer network for a shallow (0–5 km) earthquake beneath the summit of Mauna Loa is about magnitude 0.5.

Figure 2 shows the cumulative number of earthquakes of magnitude equal to or greater than 2.0 at three different depths (shallow, 0–5 km; intermediate, 5–13 km; deep, 13–50 km) beneath Mauna Loa since 1962. Between 1962 and 1974, the rate of events in all three categories was about the same—only 2 to 3 earthquakes per year within each depth range. Beginning in 1974, however, the number of intermediate-depth earthquakes picked up sharply and was soon followed by an even larger increase in shallow earthquakes. During late 1974 and early 1975, the total number of microearthquakes recorded beneath Mauna Loa commonly exceeded several hundred per day. Intense swarms occurred in August and December 1974, and again from February through June 1975; the eruption began on July 5, 1975. Numerous microearthquakes and harmonic tremor accompanied this 20-hour eruption and continued until July 12, after lava emission had ceased. After that date, shallow earthquakes dropped to a very low rate, but intermediate-depth earthquakes continued at a fairly steady rate of 7 to 8 per year following the eruption. The number of deeper earthquakes per year was not affected by the eruption. Shallow earthquakes began to increase again in mid-1980, and their rate has generally continued to increase since then.

Figure 3 plots earthquake epicenters with respect to the summit caldera and rift zones of Mauna Loa. The principal pattern of shallow earthquakes (plus-sign symbols, 5–10-km depth) is a diffuse cluster slightly larger in diameter than the combined caldera and eastern ring fracture. Even though this shallow earthquake zone does not exactly coincide with the caldera, the zone is clearly related to the summit area of Mauna Loa. The other major cluster of epicenters (open-square symbols, 5–13-km depth) is 6 to 7 km west north-

Article (*cont. on p. 546*)

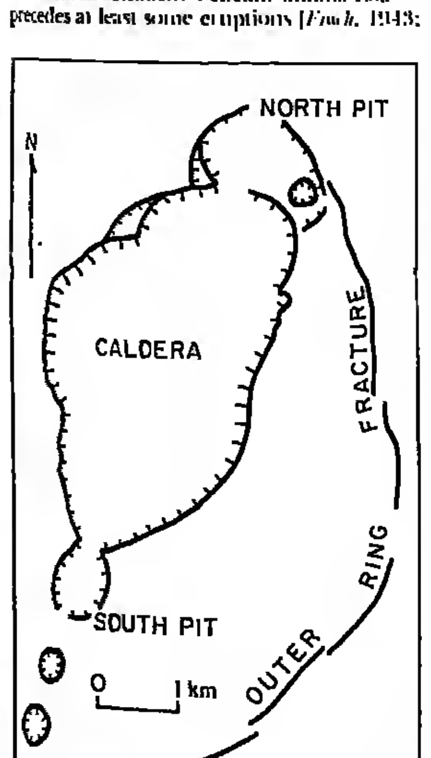

Fig. 1. Mauna Loa's summit caldera. Cliffs on west side of collapse caldera are as much as 180 m high. Lineations of fractures, craters, and vents called rift zones extend northeastward and southwestward from the caldera. Outer ring fracture is a zone of flexure and faulting with a few meters subsidence on the caldera side.

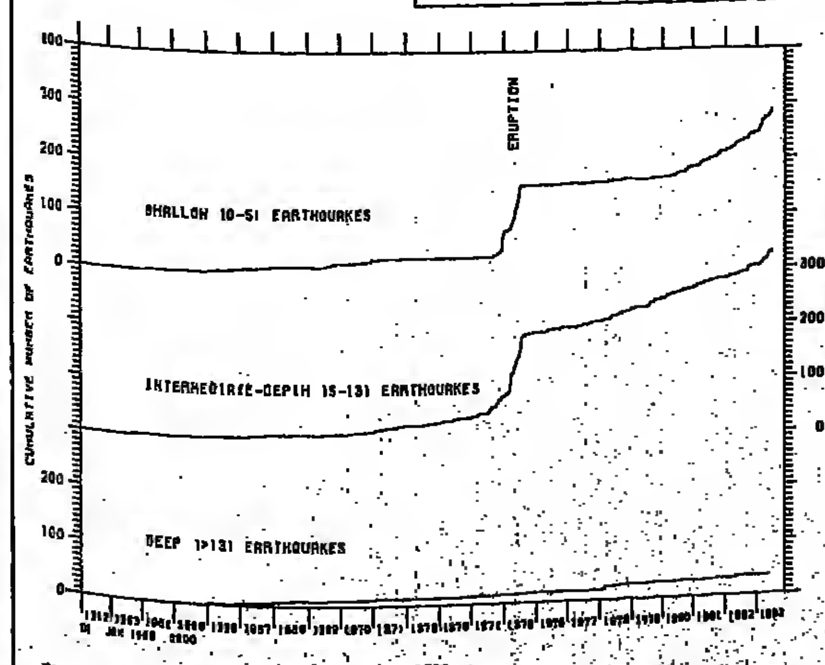

Fig. 2. Cumulative number of earthquakes of magnitude equal to or greater than 2.0 beneath summit region of Mauna Loa, plotted against time.

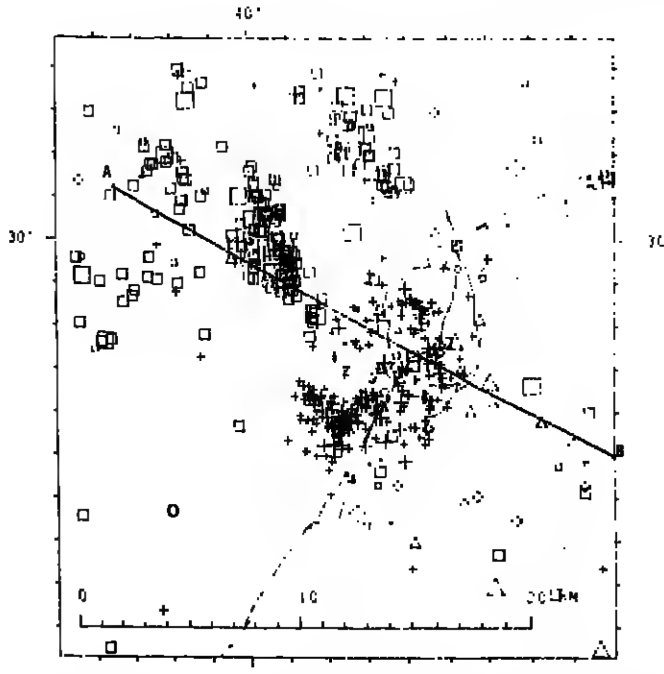

Fig. 3. Earthquake epicenters in summit area of Mauna Loa from January 1962 through May 1983. Plus signs, shallow (0–5 km) earthquakes; open squares, intermediate-depth (5–13 km) earthquakes; open diamonds, deeper (13–20 km) earthquakes; open triangles, deepest (20–50 km) earthquakes. Size of each symbol is an indication of magnitude: smallest marks represent earthquakes of magnitude 2.0 to 2.9, and largest marks represent earthquakes of magnitude 4.0 to 4.9. A–B, line of cross section in Figure 4. Lines extending northeastward and southwestward from the summit caldera denote surface fractures along rift zones.

Editorial

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Physical Properties of Rocks

6110 Elasticity, Fracture, and Flow
EFFECTS OF ZETA POTENTIAL ON MICROCRACK GROWTH IN ROCK UNDER RELATIVELY LOW UNIAXIAL COMPRESSION
T. Ishido (Geological Survey of Japan, Yatabe, Tsukuba, Ibaraki-ken, 305 Japan) and O. Nishizawa

The seismic velocity, attenuation and acoustic emission were measured to detect and monitor microcrack growth in samples of Inada granite as they were held under constant uniaxial compression. The samples were saturated with two kinds of aqueous solutions, aluminum nitrate solutions and potassium nitrate solutions, and the ζ potentials at the rock (mineral)-water interface were varied with different concentration of the solutions. [illegible]

6110 Fracture
EFFECTS OF CHEMICAL ENVIRONMENTS ON SLOW CRACK GROWTH IN GLASSES AND CERAMICS
S. W. Freiman [illegible]

[illegible] chemical species on crack growth are discussed. Finally, the complications introduced by the presence of grain boundaries in polycrystalline ceramics are pointed out. (Ceramics, crack growth, glass).
J. Geophys. Res., Red, Paper 3B1061

Social Sciences

1310 Economics
A MODEL OF HUMAN RESPONSE TO FLOOD WARNINGS FOR SYSTEM EVALUATION
W. E. Farrell (Systems and Industrial Engineering Department, University of Arizona, Tucson, Arizona, 85721) and R. Krzysztofowicz

A behavioral model of human response to flood warnings is developed as a component of a methodology for evaluation of the performance of flood forecast-response systems. A floodplain dweller [illegible] sequence of flood warnings by taking preventive [illegible] (such as evacuation, flood proofing, shutdown [illegible] (utility) in order to reduce his loss. The [illegible] meant to mimic the actual response behavior of the floodplain dweller or to predict such behavior [illegible] future system conditions. It is built of [illegible] representations of four interconnected cognitive [illegible] elements of response: (1) uncertainty about [illegible] tion prior to a flood, (2) sequential information on warnings during a flood, (3) response [illegible] (4) learning after a flood. Results of an [illegible] and qualitative verification of the model are discussed.
Water Resour. Res., Paper 3W1295

Article *(cont. from p. 545)*

west of the center of the caldera, at a depth of about 5 to 7 km. A third cluster of earthquake sources (open-triangle symbols, below 20-km depth), evident only in cross section (Figure 4), occurs beneath Mauna Loa's summit at a depth of about 40 km.

Figure 5 plots the earthquake epicenters on Mauna Loa during the 18-month period before the July 1975 eruption, and Figure 6 plots those during the past 18 months (December 1981 through May 1983). The total number of earthquakes is lower during the past 18 months, and many of the shallow earthquakes are more tightly clustered on the southwest side of the caldera. The overall patterns of seismicity, however, are generally similar.

The shallow earthquakes in the summit area are interpreted to occur in brittle rocks capping a zone of magma storage. The stresses causing these earthquakes apparently arise from changes in pressure and volume of the magma reservoir as well as from steep thermal gradients.

The intermediate-depth earthquakes west of the summit may be caused by stresses from the wedging effects of shallow dikes emplaced along the summit caldera and rift zones. The upper parts of Mauna Loa must spread horizontally in a northwestward or southeastward direction to accommodate the cumulative thickness of dikes in the rift zone. These 1- to 2-m-thick dikes make up a zone a few kilometers wide, emplaced over the past 10,000 to 100,000 years.

The deeper cluster of earthquake hypocenters, about 40 km beneath the summit, may be caused by the opening and closing of deep feeder conduits between the mantle magma source and the higher magma-storage reservoirs. The low but continuous rate of these deep earthquakes supports an interpretation of a fairly steady magma supply into Mauna Loa from a deep source. This magma is then stored in higher level reservoirs and released intermittently to the surface to generate eruptions.

The zones with very few or no earthquake hypocenters may be either zones of low stress or zones with low rigidity. The empty zone between the shallow and deep clusters of earthquake hypocenters directly beneath the caldera (Figure 4) is unlikely to be a zone of low or unchanging stresses. This zone is more probably a region of low rigidity occupied, at least in part, by magma.

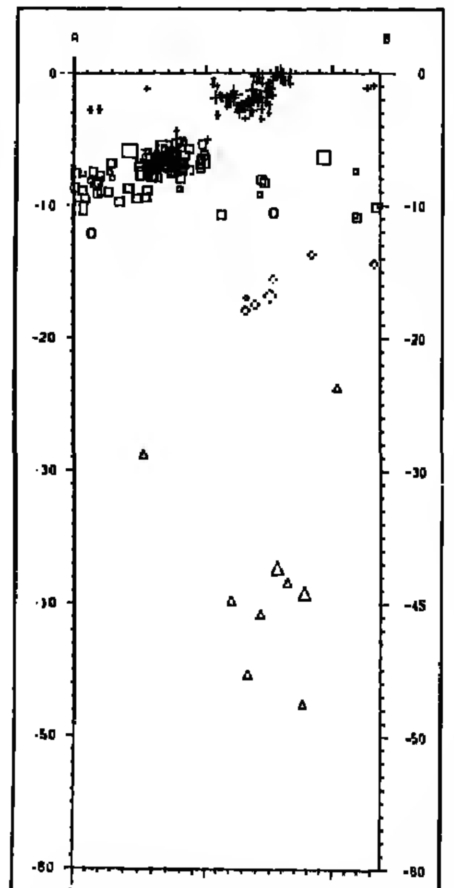

Fig. 4. Cross section of earthquake hypocenters within 2.5 km of line A–B in Figure 3. Symbols same as in Figure 3.

Ground Deformation

Leveling lines and EDM-survey lines near and across the caldera were started in 1964. These monitors showed no significant changes until 1974 and 1975, when the amount of extension of some of the cross-caldera lines amounted to slightly more than 100 mm. Figure 7 plots the locations of the present leveling, tilt, and EDM stations on Mauna Loa, many of which were established just before or after the 1975 eruption. Figure 8 plots the sudden widening of the caldera by at least 800 mm in 1975; that dilation was apparently caused by emplacement of the dike that fed the summit eruption of July 5–6, 1975. After this eruption, extension of the cross-caldera lines continued at a rate of about 200 mm yr^{-1} into 1976 and has continued since then at rates of about 20 to 50 mm yr^{-1}.

The spirit-level tilt measurements are made by precise, repeated optical levels on stadia rods placed at bench marks arranged in a triangle with approximately 30- to 40-m-base legs [*Yamashita*, 1981]. This technique has a precision of about 10 microradians. Figure 9 plots tilt-measurement results with rate changes similar to those shown by the EDM data plotted in Figure 8. Rapid outward tilt (inflation) occurred for 1 year after the eruption, followed by more moderate, though continuous, inflation since 1976.

Figures 10 through 13 show the total leveling, tilt, and EDM changes from 1977 to 1981. Figure 10 compares the theoretical uplift from a pressure increase at 3.1-km depth [*Mogi*, 1958] with the observed inflation. Figure 11 shows the observed extensions across the caldera, and the corresponding best-fit displacements are shown as solid vectors in Figure 12. The dashed vectors in Figure 12 are those expected from the theoretical inflation of the surface of an elastic half-space due to an increase in pressure 3.2 km beneath the apex of inflation. Figure 13 compares the observed tilt changes (solid vectors) with those predicted by the elastic model (dashed vectors). These data alone indicate a more shallow depth (2.6 km) to the pressure source beneath the apex of inflation.

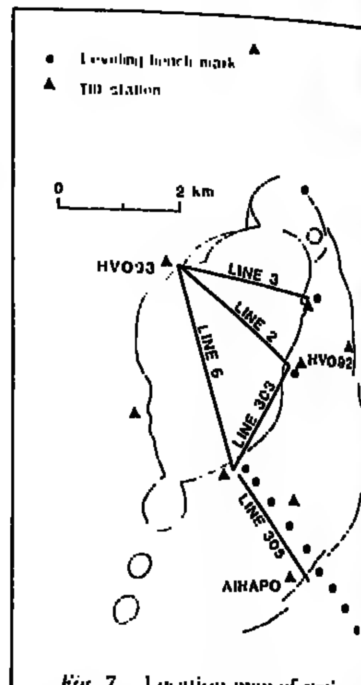

Fig. 7. Location map of stations for surface-deformation measurements in summit area of Mauna Loa.

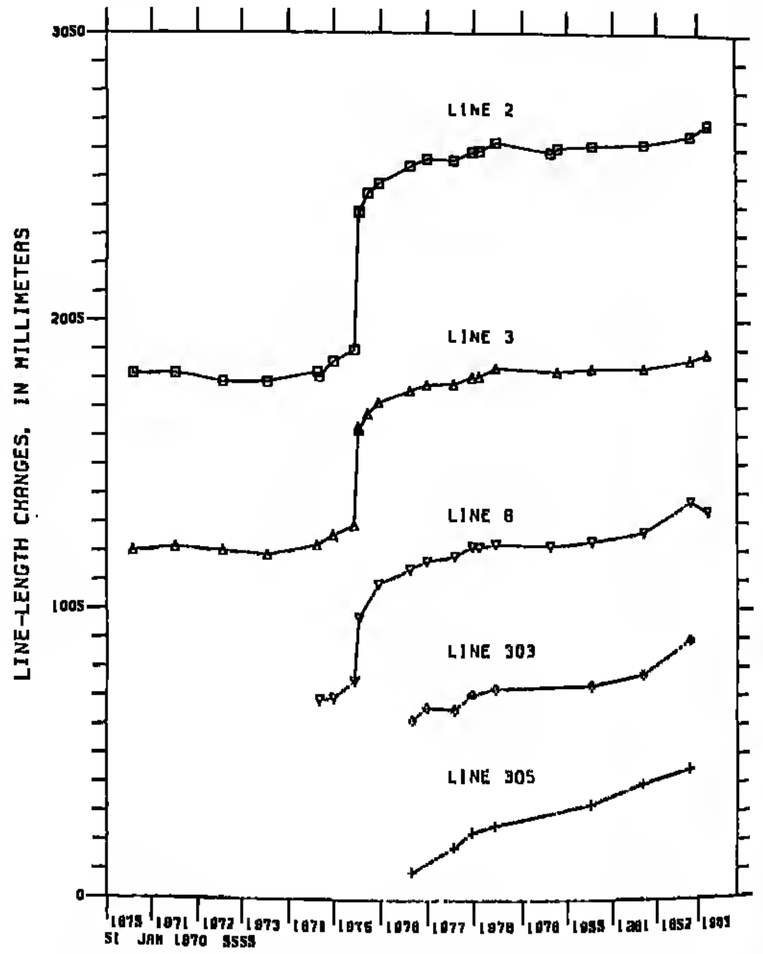

Fig. 8. Changes in EDM-survey lines across summit area of Mauna Loa (See Figure 7 for locations of lines). Sudden extensions in 1975 were caused by emplacement of dike that fed the eruption. Persistent extension since 1975 indicates continuing inflation of summit region of Mauna Loa.

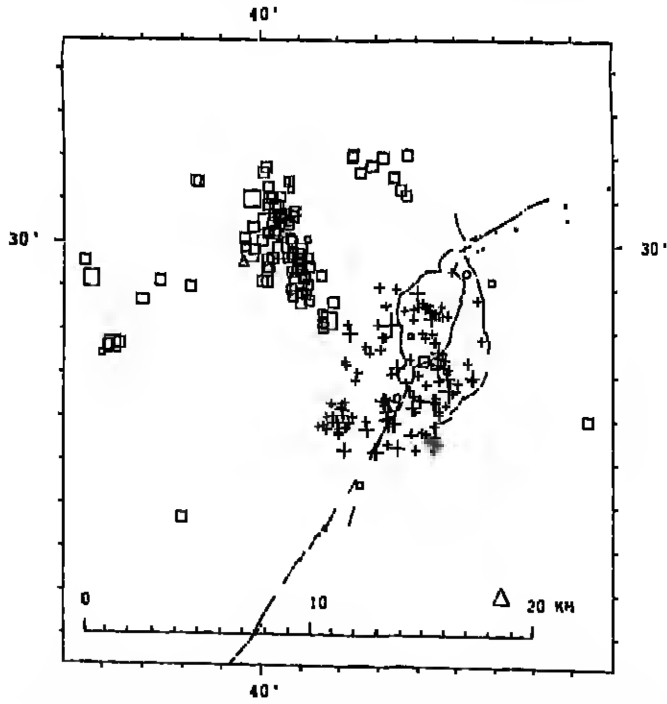

Fig. 5. Earthquake epicenters in summit area of Mauna Loa from January 1974 through June 1975. Symbols same as in Figure 3.

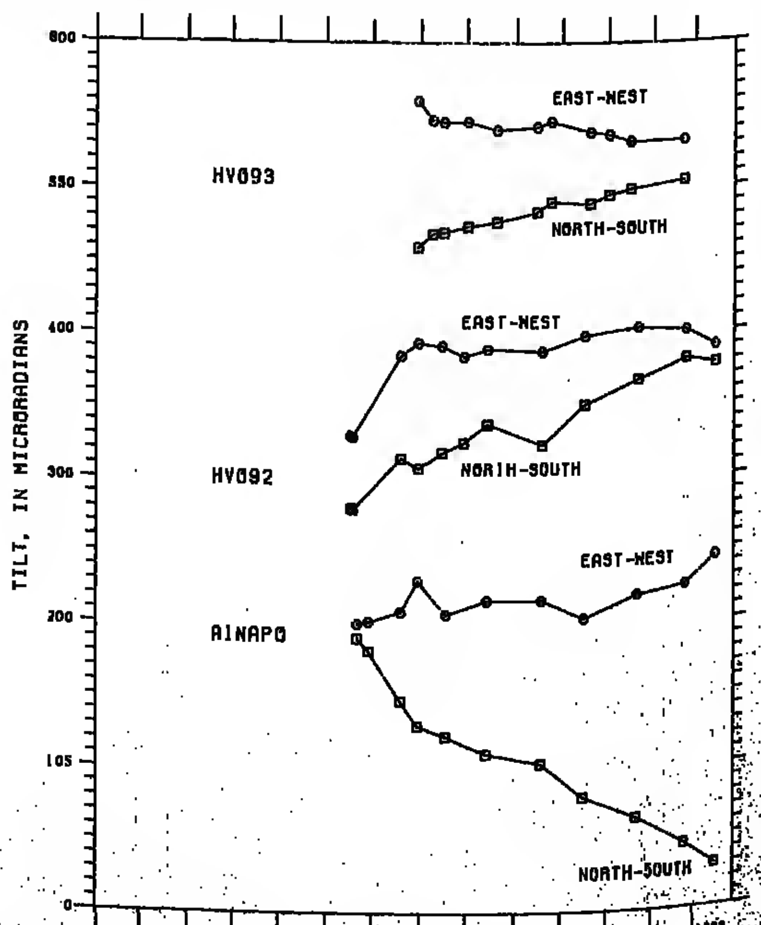

Fig. 9. Changes in north-south (up-down) and east-west (up-down) tilt components in summit area of Mauna Loa since 1975 (see Figure 7 for locations of stations). Station HV093 shows persistent northwestward tilting, station HV092 persistent north-northwestward tilting, and station AINAPO persistent south-southeastward tilting. These tilt changes indicate inflation of summit region of Mauna Loa.

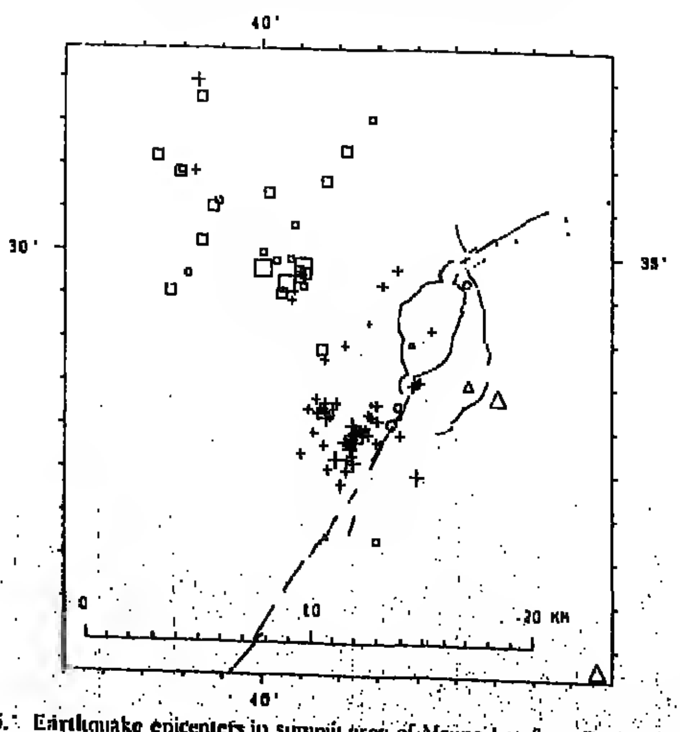

Fig. 6. Earthquake epicenters in summit area of Mauna Loa from December 1981 through May 1983. Symbols same as in Figure 3.

Table 1 lists the various parameters obtained by inverting the leveling, tilt, and EDM data separately, and by simultaneous inversion of all the deformation data [*Dvorak et al.*, 1983]. The longitude and latitude of the apex of inflation are x and y, respectively, and z is the depth to the point pressure source beneath the apex of inflation. The volume values show for each data source the total volume of swelling, which represents the minimum volume of increased magma storage at depths of 3 to 4 km. The bulk rigidity and compressibility of the system are not known, and so accurate estimates cannot be made of magma-volume changes. The base values show the amounts of theoretical uplift of the reference bench mark needed to make the elastic model best fit the observations. The sigma values show the quality of fit between the least-squares model and the observations.

It is clear from all the deformation measurements that they fit a simple, elastic model reasonably well and that they define a common center of uplift and a surprisingly shallow pressure source. The similarity between the surface-deformation pattern of the summit areas of Mauna Loa and Kilauea volcanos is striking. On Kilauea, the pressure source is about 3 km deep [*Fiske and Kinoshita*, 1969; *Swanson et al.*, 1976], and inflations and deflations of the summit area create leveling, tilt, and EDM changes with similar patterns to those measured on Mauna Loa. Even though the lower zones of the magma chambers beneath Mauna Loa and Kilauea reach to several kilometers depth on the basis of seismic evidence [*Koyanagi et al.*, 1975; *Ryan et al.*, 1981], the changes in surface deformation on both volcanoes indicate that the zone of active magma input and removal is quite shallow.

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Cover. Sulfuric acid aerosol droplets, collected with wire impactors over Baja California, before and after stratospheric perturbation by El Chichón. Pictures in the left column are from a collection taken April 19, 1982, at 21,300 m, after the main eruption of April 4, but before arrival of any part of the El Chichón cloud. Acid droplets are small and scarce (the linearly-arranged depressions are pits in the sample substrate) and represent a background aerosol amounting to about 0.7 ppb by mass of $SO_4^{=}$. Greatly increased El Chichón-derived aerosol burden is, however, evident on December 12 at 20,700 m. (right column). By this time significant amounts of the SO_2 gas introduced by El Chichón had converted to H_2SO_4. Droplets are large and abundant; the $SO_4^{=}$ level is 49 ppb. These examples are from a collection program using NASA U-2 aircraft. Thin sampling wires mounted in support rings are exposed at preselected altitudes; aerosol droplets impact the wires at aircraft speed, which is usually 740 km per hour. (Photographs courtesy of K. G. Snetsinger, G. V. Ferry, and V. R. Oberbeck, NASA Ames Research Center, Moffett Field, California; and D. M. Hayes, EAL Corporation, Richmond, California.)

The major difference between Mauna Loa and Kilauea, indicated by the surface-deformation changes, is the rate of magma input. Table 1 shows that the recent magma supply rate to Mauna Loa causes an average surface-volume change of about 4×10^6 m^3 yr^{-1}. The actual volume of magma must equal or exceed this volume of inflation. During the same period, surface-volume changes at the summit of Kilauea indicate a magma supply of at least 60×10^6 m^3 yr^{-1} [*Dzurisin and Koyanagi*, 1981].

The similarity of the morphology and evolution of the calderas on Mauna Loa and Kilauea, and the recent discovery of an apparent caldera on Loihi, the young submarine volcano 50 km south of Kilauea [*Malahoff et al.*, 1982], indicate that the filling and collapse of calderas is a longlasting and common mechanism in the growth of Hawaiian volcanos. This conclusion implies that the magma-storage zone grows upward from the old sea bottom as the volcano gains in elevation. This upward growth could lead to the evolution of a complex magma reservoir system whose diameter is about the same as that of the caldera and whose vertical height would extend from at least the old sea bottom (5 km below sea level) to 3 km beneath the summit of the volcano. The long-term supply of magma from the upper mantle at depths of about 50 km into this more shallow magma-reservoir complex would tend to form even deeper and wider roots to the total magma-reservoir system beneath the caldera. Figure 14 is a schematic cross section at true scale of one possible model of the magma-reservoir system beneath Mauna Loa. Zone A, the more active part of the magma-reservoir system, slowly inflates between eruptions, and rapidly deflates to supply magma to flank eruptions from the rift zones. Zone B, which also is a region of magma storage, is less active than zone A in the sense of less change in storage volume over time. Both zones are inferred to be networks of molten intrusions separated by screens of hot but more solid rock.

Increased Eruption Probability

Mauna Loa last erupted in July 1975. That eruption was preceded by an increase in both shallow and intermediate-depth earthquakes, and by extension of EDM-survey lines across the caldera (Figures 2 and 8). Since 1980, and especially since early 1983, the number of shallow earthquakes beneath Mauna Loa has been increasing again. Intermediate-depth earthquakes have continued at a higher rate during the period from 1978 to the present than during 1971 to 1973 but have not shown the same pattern of increase as they did in 1974. Figure 8 (with the exception of line 6) also shows a recent increase in the rate of extension of EDM-survey lines across the summit caldera of Mauna Loa.

The near-surface strain from the apparent intrusion of magma beneath the summit region of Mauna Loa has recently shown an accelerating trend on the basis of both seismic and ground-surface-deformation data. But since the present strength of Mauna Loa is not known, no precise forecast of the next eruption can be made. However, if the present rate of strain continues to increase (and we emphasize the "if"), the probability significantly increases for an eruption of Mauna Loa during the next 2 years.

References

Dvorak, J. J., A. T. Okamura, and J. Dieterich, Analysis of surface deformation data, Kilauea Volcano, Hawaii, *J. Geophys. Res.*, *88*, in press, 1983.

Dzurisin, D., and R. Y. Koyanagi, Changed magma budget since 1975 at Kilauea Volcano, Hawaii, *U.S. Geol. Surv. Open-File Rep.*, *81-571*, 45 pp., 1981.

Finch, R. H., The seismic prelude to the 1942 eruption of Mauna Loa, *Bull. Seismol. Soc. Am.*, *33*, 237–241, 1943.

Fiske, R. S., and W. T. Kinoshita, Inflation of Kilauea Volcano prior to its 1967–1968 eruption, *Science*, *165*, 341–349, 1969.

Koyanagi, R. Y., E. T. Endo, and J. S. Ebisu, Reawakening of Mauna Loa Volcano, Hawaii: A preliminary evaluation of seismic evidence, *Geophys. Res. Lett.*, *2*, 405–408, 1975.

Lockwood, J. P., R. Y. Koyanagi, R. I. Tilling, R. T. Holcomb, and D. W. Peterson, Mauna Loa threatening, *Geotimes*, *21*(6) 12–15, 1976.

Macdonald, G. A., Activity of Hawaiian volcanoes during the years 1940–1950, *Bull. Volcanol.*, *Ser. 2*, *15*, 119–179, 1954.

Macdonald, G. A., Geologic map of the Mauna Loa quadrangle, Hawaii, scale 1:24,000, *Geol. Quad. Map GQ-897*, U.S. Geol. Surv., Reston, Va., 1971.

Malahoff, A., G. M. McMurtry, J. C. Wiltshire, and H. W. Yeh, Geology and chemistry of hydrothermal deposits from active submarine volcano Loihi, Hawaii, *Nature*, *298*, 234–239, 1982.

Mogi, K., Relations between the eruptions of various volcanoes and the deformation of the ground surface around them, Univ. Tokyo, *Bull. Earthquake Res. Inst., Univ. Tokyo*, *36*, 99–134, 1958.

Ryan, M. P., R. Y. Koyanagi, and R. S. Fiske, Modeling the three-dimensional structure of macroscopic magma transport systems: Application to Kilauea Volcano, Hawaii, *J. Geophys. Res.*, *86*, 7111–7129, 1981.

Swanson, D. A., W. A. Duffield, and R. S. Fiske, Displacement of the south flank of Kilauea Volcano: The result of forceful intrusion of magma into the rift zones, *U.S. Geol. Surv. Prof. Pap.*, *963*, 39 pp., 1976.

Yamashita, K. M., Dry tilt: A ground deformation monitor as applied to active volcanoes in Hawaii, *U.S. Geol. Surv. Open-File Rep.*, *81-523*, 14 pp., 1981.

Bob Decker *is scientist-in-charge of the U.S. Geological Survey's Hawaiian Volcano Observatory (HVO), a position he has held since 1979.* Bob Koyanagi *is senior seismologist and has been at HVO since 1961.* John Dvorak *specializes in interpretation of surface-deformation data; he has been at HVO since 1981.* Jack Lockwood *is the dean of Mauna Loa geology and has been at HVO since 1974.* Arnold Okamura *has been collecting and analyzing deformation data on Hawaiian volcanoes since 1961.* Ken Yamashita *is principal surveyor; he has been making surface-deformation measurements at HVO since 1965.* Wil Tanigawa *analyzes the records from the 47 seismic stations on Hawaii; he has been at HVO since 1979.*

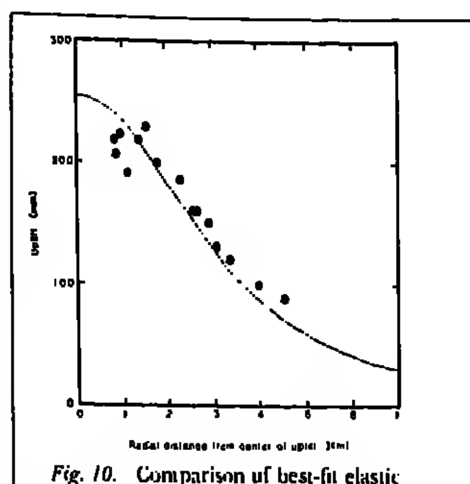

Fig. 10. Comparison of best-fit elastic deformation model (solid curve) with observed elevation changes from leveling surveys in summit area of Mauna Loa from 1977 to 1981 (see Figure 7 for locations of leveling bench marks). Reference bench mark is the most northerly dot in Figure 7. Depth to pressure source beneath summit for this model is 3.1 km.

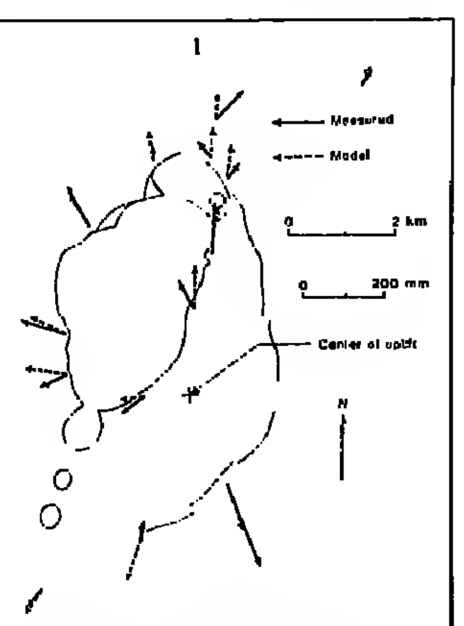

Fig. 12. Horizontal displacements calculated from EDM-survey line-length changes in Figure 10 (solid vectors) in comparison with those from best-fit elastic deformation model (dashed vectors). Vector scale shows displacement amplitudes (in millimeters) from 1977 to 1981. Center of uplift (apex of inflation) is surface projection of a buried point source of pressure 3.2 km beneath summit of Mauna Loa.

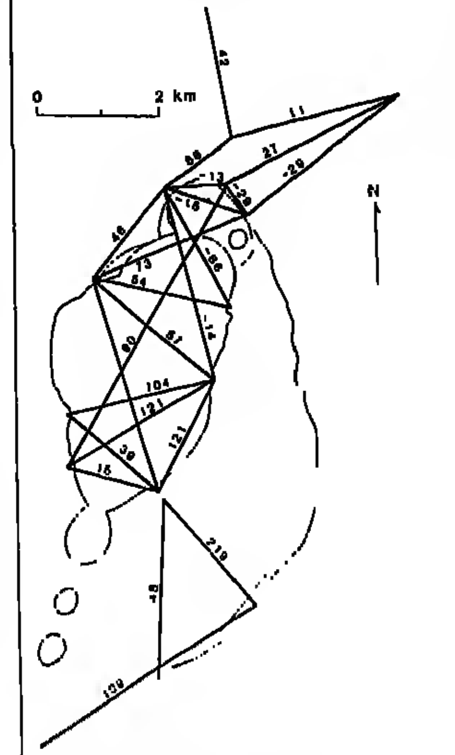

Fig. 11. Changes in line length of EDM-survey lines in summit area of Mauna Loa from 1977 to 1981. Positive values are extensions (in millimeters), and negative values are contractions (in millimeters). Maximum measured change is 100 microstrain units on line 305 (Figure 7), southeast of the caldera.

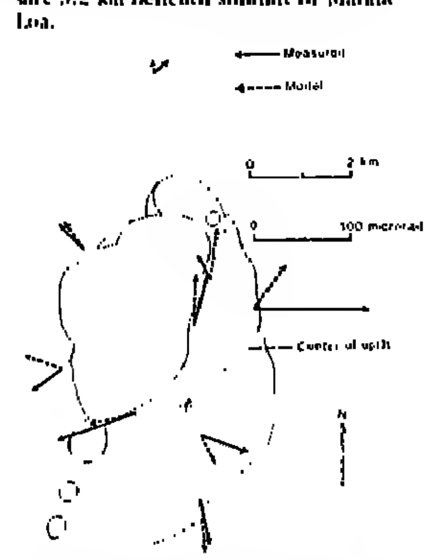

Fig. 13. Measured tilt vectors (solid) in comparison with best-fit elastic-deformation-model vectors (dashed). Tilt scale shows vector amplitudes (in microradians) between 1977 and 1981. Center of uplift is nearly identical to that independently determined in Figure 12, but buried point source of pressure for tilt data alone is 2.6 km.

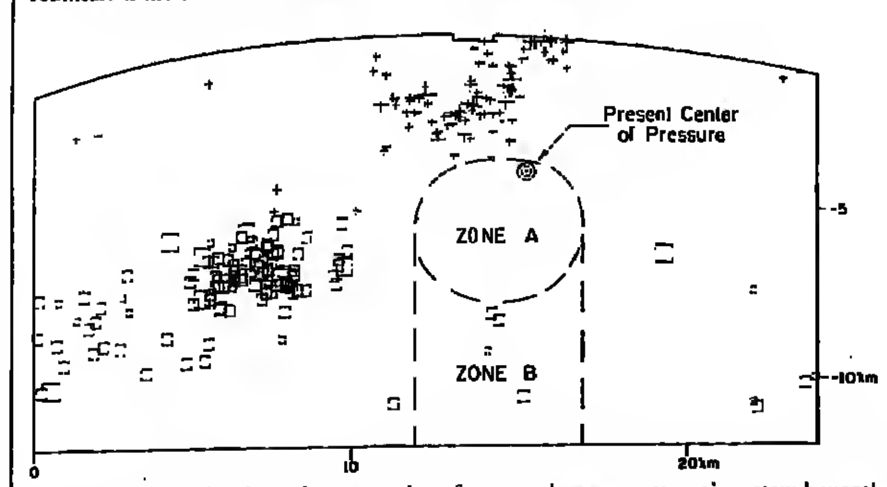

Fig. 14. True-scale schematic cross section of proposed magma-reservoir system beneath summit of Mauna Loa. Cross section and earthquake hypocenters same as in upper 12 km of Figure 4.

TABLE 1. Mauna Loa Geodetic Data, 1977–1981

Data	x: Longitude W	x: km	y: Latitude N	y: km	z, km	Volume, 10^6 m^3	Base, mm	σ Level, mm	σ EDM: mm	σ EDM: μ strain	σ Tilt, μ rad
Leveling	155°34.5'	±0.2	19°27.5'	±0.2	3.1 ± 0.5	17 ± 3	59 ± 24	4			
Tilt	155°35.2'	±0.6	19°27.5'	±0.6	2.6 ± 1.2	8 ± 5					27
EDM	155°35.1'	±0.7	19°27.2'	±0.4	3.2 ± 1.2	19 ± 8			37	25	
All	155°35.0'	±0.4	19°27.3'	±0.3	3.9 ± 0.8	22 ± 6	88 ± 50	16	40	26	30

News

In Congress

Budget Update for NOAA, USGS

Among the agenda items facing Congress as it reconvenes this week are the fiscal 1984 budgets for the National Oceanic and Atmospheric Administration (NOAA), which is part of the Department of Commerce, and for the U.S. Geological Survey (USGS), which is within the Department of the Interior. Fiscal year 1984 begins October 1, 1983. As Congress rolls up its shirtsleeves and gets down to business, *Eos* presents a status report on the two agency budgets.

Both House and Senate appropriations committees have finished their work on the NOAA budget, which had been targeted by President Ronald Reagan for a $799.8 million appropriation request (program level of $843.2 million) in his proposed fiscal 1984 budget (*Eos*, February 15, 1983, p. 65). The House appropriation for NOAA (H.R. 3134 and H.R. 3222) is $998.5 million, with a program level of $1043.9 million. The Senate Appropriations Committee set its appropriation (S. 1721) at $987.8 million, with a program level of $1041.0 million.

Appropriations are the amount of money the government will use from the treasury; program levels represent the actual money available. Program levels include not only appropriations from the federal government, but also supplementals, residuals from previous years, offsets from various funds, etc. (*Eos*, February 9, 1982, p. 148).

If the bills go to the floor of their respective houses and are passed, the differences between the House and Senate versions of the NOAA budget will be ironed out in a conference committee. A continuing resolution may be necessary, though, to keep NOAA running if the appropriations bills are not signed into law when the fiscal year begins. Table 1 compares the Reagan Administration request for program levels within the operations, research, and facilities (ORF) account, NOAA's largest, with the program levels from the House and Senate.

Appropriations for USGS have been passed by the full House as part of the Interior Department budget (H.R. 3363). On July 19, the Senate Appropriations Committee sent the bill to the full Senate, where it has since been under consideration. The Senate is expected to continue its consideration of the Interior budget when it reconvenes this week. The House set the USGS appropriation at $383.5 million and its program level at $407.5 million, while the Senate Appropriations Committee agreed on an appropriation of $364.5 million and a program level of $388.5 million. Residual funds from previous years for the National Petroleum Reserve in Alaska are responsible for the $24 million difference between each house's appropriation and program levels. The differences between the House and Senate versions will have to be ironed out in a conference committee once the Senate passes the bill. Table 2 compares the Reagan Administration proposed budget with the House and Senate versions.—*BTR*

TABLE 1. NOAA Fiscal 1984 Budget Status: Operations, Research, and Facilities (ORF), in Thousands

Activity	Reagan Proposal	House Version*	Senate Version†
Ocean and Coastal Programs			
Nonliving marine resources	1,761	2,561	3,761
Ocean research	23,452	37,884	39,014
Ocean services	13,237	13,021	15,280
Sea Grant	0	35,000	38,000
Coastal zone management‡	6,050		
Mapping, charting, and geodesy	72,619	45,139	47,089
Subtotal	117,125	133,605	143,144
Marine Fishery Resource Programs	92,444	141,550	144,292
Atmospheric Programs			
Public warning & forecasting services	264,936	298,581	301,959
Atmospheric and hydrologic research	44,561	49,696	51,496
Subtotal	309,497	348,277	353,455
Satellite and Environmental Data and Information Services			
Satellite services	73,279	71,479	71,479
Satellite systems	117,361	137,361	137,361
Data & information systems	22,313	22,313	22,791
Subtotal	212,953	231,153	231,631
Program Support	93,355	104,831	113,210
Total, ORF	827,372	959,436	985,732

Numbers may not total because of rounding.
*These numbers represent the program levels based on House budget appropriations for NOAA in H.R. 3134, reported by the House Appropriations Committee (Committee Report 98-234) on May 26 and in H.R. 3222 (Committee Report 98-232), June 3.
†These numbers represent the program levels based on Senate budget appropriations for NOAA (S. 1721), reported by the Senate Appropriations Committee (Committee Report 98-206) on July 28.
‡Both the House and Senate put Coastal Zone Management into its own account. The House set the program level for CZM at roughly $37.4 million, while the Senate set the program level at $28.4 million. The total listed for the Reagan request for Ocean and Coastal Programs includes CZM; the totals for Congress' levels do not.

TABLE 2. USGS Fiscal 1984 Budget Status, in Millions

Activity	Reagan Proposal	House Version*	Senate Version†
Geologic and Mineral Resource Surveys			
Geologic hazards	40.7	52.4	48.7
Land resource surveys	16.7	18.1	16.7
Mineral resource surveys	45.3	45.3	45.3
Energy geologic surveys	25.5	34.0	29.5
Offshore geologic surveys	13.7	16.2	18.7
Subtotal	141.9	166.0	158.9
Water Resources Investigations			
National water data system/federal program	55.4	63.0	56.7
National water data system: federal-state cooperative program	47.1	49.6	47.6
Energy hydrology	9.6	12.6	12.1
Subtotal	112.1	125.2	116.4
National Mapping Program	77.9	93.1	90.0
Facilities	13.2	13.2	13.2
General Administration	14.2	13.5	15.6
Total, USGS	363.3‡	407.5§	388.3§

Numbers may not total because of rounding.
*These numbers represent the program levels based on budget appropriations contained in H.R. 3363 and passed by the House of Representatives on June 28. Includes $24 million from residual funds for National Petroleum Reserve in Alaska (NPRA).
†These figures represent the program levels based on budget appropriations arrived at by the Senate Appropriations Committee (Committee Report 98-194) and reported to the Senate floor July 19. Includes $24 million for NPRA.
‡Does not include money for NPRA. This total also includes $6 million for digital cartography activities, which in previous years had been included with the National Mapping Program activity but was listed separately in the fiscal 1984 Reagan proposal.
§These totals, which are not the sum of the activity levels, include a $5.6 million reduction for office rental costs.

Seabed Heat Transfer

The Subseabed Disposal Program (SDP) includes a set of heat-transfer experiments on the ocean floor, planned for 1986. The concept is to provide data on the local heating of seabed sediment released by buried radioactive waste materials. The In Situ Heat Transfer Experiment (ISHTE) involves placing a 400-W isotopic heat source and related equipment frame on the seabed at a depth of approximately 6000 m. Data will be recorded at the site, some of which will be transmitted to a surface vessel by acoustic telemetry. The entire apparatus will be recovered within 1 year.

The program is being run as a collaborative effort among the Sandia National Laboratories, the University of Washington Applied Physics Laboratory, the University of Rhode Island Marine Geomechanics Laboratory, the Woods Hole Oceanographic Institution, and the Naval Ocean Research and Development Activity. The comprehensive ISHTE will measure the thermal field, the effective thermal conductivity of the sediment, pore pressure, radionuclide migration, and sediment shear strength and provide chemical analysis of pore water and sediment. Nuclear wastes may be stored in the future in canisters buried in the ocean floor clay sediments, and thus the clays must act as a major containment barrier for 10^4 to 10^5 years. The following questions are under study:

- The capacity of the sediment to transport thermal energy away from the canister to prevent overheating
- The capability of the sediment to securely restrain the canister from moving
- The chemical and mineralogical changes induced by thermally activated reactions
- Pressure buildup caused by thermal expansion of pore water
- The permeability change of the sediment induced by pore-water expansion and chemical alteration
- The radionuclide sorption characteristics of the sediments both in the heated region and the cooler regions remote from the canister

According to a report prepared by C. Mark Percival of Sandia Laboratories (SAND83-0202, May 1983), "The interactions are being investigated by analytical methods, computer models, and supporting laboratory experiments. The overall objectives of the model and laboratory studies are to develop means of predicting the long-term response of the waste/sediment system in order to define problem areas, propose solutions, develop an optimum system design, and assure that the design is safe.

"The approach to the model development," continues Percival, "is to form a physical/mathematical/computer description of a process; measure, as well as possible, associated phenomena and properties in the laboratory; make predictions and run confirming in situ experiments; and, finally, modify or improve the fundamental knowledge of the process and the predictive tools if required. At present, data and models to describe the heat-transfer, fluid-flow, geochemical, and radionuclide-migration processes in the seabed sediment are under development."

The primary objectives of ISHTE are: (1) to provide data on the effects of heating on the response (temperature excursions, pore pressure variations, pore fluid motion, tracer particle transport, thermochemical reactions, etc.) of in situ sediment for use in verifying laboratory experimental approaches and computer models; (2) to provide an opportunity to observe any unanticipated phenomena which may occur; and (3) to develop and demonstrate the technology necessary to perform waste isolation oriented experiments on and in the ocean bed at depths of 6000 m for an extended period of time, obtain large quantities of data, and recover the experiment.

Two points must be emphasized for this experiment. First, ISHTE is not a simulation of a waste emplacement. No effort has been made to scale canister sizes, power, or emplacement depths. The experiment is designed only to provide a body of data to test and to verify the accuracy and applicability of laboratory experimental approaches and computer models. Second, ISHTE is not solely a heat-transfer experiment. In addition to the energy transport data, information will be obtained on pore-fluid response, sediment/seawater/heater thermochemical reactions, sediment thermal stability, and the transport and sorption of injected tracer species.

Because of the high temperatures to be generated during ISHTE and the need for fine-grained, low-permeability sediments, a considerable effort has been devoted to selection of a suitable site. One of the controlling aspects is that the water pressure must be high enough to prevent boiling and possible abnormal thermally induced volume increases.

Several oceanographic research cruises have been concentrated in a region about 1800 km north of Hawaii in an area designated as MPG-1 between latitudes 30° and 31°30'N and longitudes 157° and 159°W. A great deal of data has been collected on the geological aspects of the region as well as the geotechnical and geochemical characteristics of the sediments to depths of over 24 m into the sediment layer. ISHTE could be performed at sites other than the proposed MPG-1 site. The site criteria listed above must be met and sufficient material characterization must be completed to provide the necessary thermal and mechanical properties for the model calculations.—*PMB*

Geoscientists Surveyed

A sociological survey of men and women geoscientists has been prepared by the Association for Women Geoscientists (AWG) in conjunction with the University of Colorado. AWG, which will mail the survey questions to its members in October, invites interested men and women who are not AWG members to request and fill out the questionnaires; it will be available October 1 from Sigrid Asher, 5801 South Williams Street, Denver, CO 80209, and must be returned by October 31, 1983.

The survey will cover both career facts and job attitudes, and the results will be analyzed by survey specialists at the University of Colorado. AWG hopes that, besides being useful for designing AWG programs to meet the needs of those queried, the survey will provide employment statistics previously unavailable.

A national roster of AWG members, listing professional activities, educational background, and technical specialties will be published this fall.

AWG, a national professional organization, encourages the participation of women in the geosciences, promotes their professional advancement, and exchanges technical and professional information. Membership in AWG is open to all who support AWG goals.

AWG has recently initiated programs targeted on the community outside of the AWG membership. In addition to the sociological survey, it is currently working with the Girl Scouts of America to develop a geology field program to be offered to Girl Scouts in 1984. By 1984, AWG will have fully established the tax-exempt AWG Education Foundation. A non-profit public corporation, the AWG Foundation will provide awards, grants and scholarships to women studying the geosciences. Special emphasis will be placed on scholarships for women re-entering the profession and women doing graduate level studies.

Founded in 1977 by a small group in the San Francisco Bay area, AWG has since expanded to a membership of nearly 1000 men and women across the United States. The AWG program includes monthly chapter meetings which feature technical presentations, career development seminars sponsored by chapters and stressing opportunities for both students and professionals; workshops; and field trips.

Other services and activities provided by AWG include the national, bimonthly newsletter, *Gaea*, and local newsletters published by the chapters. [*Gaea*, pronounced "*jee-a*," is the name of the ancient Greek goddess of earth and is the root of the prefix "geo-".] A job clearinghouse, breakfasts, and booths at national SEG, AAPG and GSA meetings, and student awards are also regular AWG activities.

For individual or institutional membership information, the address of the chapter nearest you, or a nonmember subscription to *Gaea*, write to: Association for Women Geoscientists, P.O. Box 1005, Menlo Park, CA 94025.

Mobile VLBI Transfer

The National Aeronautics and Space Administration (NASA) has agreed to transfer Mobile Very Long Baseline Interferometry (VLBI) equipment and operations to the National Oceanic and Atmospheric Administration (NOAA). NOAA will use these mobile systems to create and maintain a National Crustal Motion Network (NCMN) and to support NASA's Crustal Dynamics Project. Consisting of several fixed VLBI sites across the United States, and 40 to 50 additional sites established by mobile VLBI, the NCMN will provide a basic terrestrial coordinate system throughout the United States that has been referenced to the inertial system defined by the fixed VLBI stations. While monitoring crustal deformation across the United States, the NCMN will also establish base stations in the National Networks of Geodetic Control that will also provide accuracy criteria for use with differential and interferometric Global Positioning System receivers. This NCMN will gain further importance as the burden of geodetic observations shifts increasingly to satellite-based techniques in the future.

The transfer to NOAA will take place from January 1983 to January 1985, during which time NOAA will provide trained operating crews and NASA will demonstrate the operational status of the systems and transfer their ownership to NOAA. These systems include three separate mobile VLBI systems as well as a fixed base station. The mobile VLBI systems consist of MV-1, the original ARIES 9-m-diameter antenna system; MV-2, the second ARIES system with a 4-m-diameter antenna; and MV-3, the ORION system with a 5-m-diameter antenna. The fixed system, designated the Mojave Base Station (MBS), uses a 12-m-diameter antenna located at the facilities of the Goldstone Deep Space Network in southern California.

All the mobile systems have been built and successfully demonstrated by the Jet Propulsion Laboratory (JPL) under contract to NASA's Crustal Dynamics Project. The Project is also responsible for the refurbishment of MBS, which will serve as the base station from which the mobile systems will be deployed and where they will be maintained between observing sessions.

The agreement calls for the transfer of MBS and MV-3 during January 1984 with transfer of MV-1 and MV-2 during January 1985. Training of a NOAA crew for MV-3 has already begun at JPL, and a contractor crew is also in training at MBS. The Geodetic Research and Development Laboratory branch of the National Geodetic Survey (NGS), National Ocean service, NOAA, will manage NOAA's mobile VLBI operation. The NOAA crew for MV-3 and the ground surveying for many of the sites is provided by the NGS Operations Branch.

VLBI measurements provide the greatest available accuracies for measuring baselines of hundreds or even thousands of kilometers. Typical uncertainties of a few centimeters will permit motions of the earth's crust along fault lines to be measured after repeated visits to selected sites over a few years. Gathering data to understand the relation between these subtle motions and earthquakes is a major impetus of the mobile VLBI program.

MV-1 was originally developed as a proof-of-concept instrument and consequently is not as highly mobile as subsequent systems. Assembling and disassembling its 9-m antenna at a new site takes about 14 days using a crew of at least four persons, along with a crane and a "cherry picker." Since 1973, MV-1 has occupied a dozen sites in California between La Jolla and San Francisco, using radio observatories in Owens Valley and Goldstone as base stations. Because of the time and expense of relocating MV-1, it is expected to serve as a semipermanent base station at Vandenberg Air Force Base through the 1988 completion of NASA's Crustal Dynamics Project.

Much greater mobility was achieved with MV-2, whose 4-m antenna system can be deployed in a few hours after arriving on site. MV-2 has been used since 1980 to occupy additional sites in California and Yuma, Arizona. MV-3 is the first mobile system designed specifically for the Crustal Dynamics Project. Designed and built entirely by JPL, it is intended to serve as a well-documented standard on which any future mobile VLBI system would be based. MV-3 began gathering data in 1982 and has greatly extended the range of mobile VLBI operations, traveling approximately 1920 km from Pasadena to Platteville, Colorado, during June 1983.

Typically, about 24 hours of continuous observations are desired at each site with about 1 or 2 days allowed before and after the observing sessions for setup, checkout, and teardown. Driven by diesel tractors, each mobile VLBI convoy includes an antenna van, electronics van, and a smaller truck. The convoy, driven by its own crew, can cover 500 to 800 km per day. Each system is self-contained, requiring no external power. Currently, observing campaigns last 1 to several weeks, with MV-2 and MV-3 each occupying about two sites per week.

Each of these systems is equipped with the now-standard Mark III VLBI Data Acquisition System featuring computer controlled observing, standard S and X Band receivers for ionospheric calibrations, radiometers for tropospheric water vapor calibration, and environmentally controlled hydrogen maser frequency standards.

The Crustal Dynamics Project observations will concentrate in California and in several other sites west of Colorado. Each summer, MV-2 and MV-3 will be shipped to Alaska for project observations there.

This news item was contributed by Gerald L. Mader, *National Geodetic Survey, NOAA, Rockville, MD 20852.*

Geophysicists

Oliver H. Gish, AGU's oldest and longest-standing member, recently celebrated his 100th birthday. A member of the Geomagnetism and Paleomagnetism section, he joined AGU in 1925.

Richard E. Hallgren, has been appointed assistant administrator for weather services at the National Oceanic and Atmospheric Administration (NOAA). He will continue to serve as Director of NOAA's National Weather Service, a position he has held since 1979. In his 19 years with NOAA Hallgren helped introduce such new technology as automatic weather stations, advanced radar systems, and computerized automation of field operations and services. He helped develop World Weather Watch, an international system that intergrates weather monitoring and forecasting systems, and directed U.S. efforts in the 1979 Global Weather Experiment that assessed the practical limits of weather forecasting.

Stephen R. Mosier, has been appointed associate vice president for international affairs for the University of Houston System. Since 1981 he has served as director of U.S.–French and U.S.–Belgian cooperative programs at the National Science Foundation. Prior to that he was director of U.S.–Japanese programs at the foundation.

Texas A&M University has announced the following promotions of AGU members:

N. L. Carter, from head, Department of Geophysics, to professor of geophysics; ***Gordon P. Eaton***, from dean of the College of Geosciences to provost and vice president for academic affairs; ***Mel Friedman***, from associate and interim dean to dean of the College of Geosciences; ***Charles M. Gilbert***, from professor of geology, VPI, to head, Department of Geology, College of Geosciences; ***Earl Hopkins***, from professor of geophysics, geography, geology, and petroleum engineering to head, Department of Geophysics; ***William J. Merrell***, from assistant department head, Department of Oceanography, to associate dean for research and programs, College of Geosciences.

Barney P. Popkin has joined the NUS Corporation as manager of hydrogeologic services. He will manage a team responsible for developing, managing, and implementing waste-management and water-resources projects throughout the U.S.

Gerald J. Wasserburg has been appointed to the newly created John D. MacArthur chair at the California Institute of Technology. The $1.2 million grant awarded to Caltech by the MacArthur Foundation allowed the university president to choose the field, the recipient, and the duration of the chair. Wasserburg, a geophysicist best known for his work on a chronology for the formation of the solar system, was involved in the Apollo program and has specialized in the analyses of interplanetary dust, meteorites, moon rocks, and terrestrial materials. The new appointment will enable Wasserburg to continue research on the applications of thermodynamic methods to geologic systems.

In Memoriam

The following AGU members are recently deceased:

Harry Larson, 88; a member of the Hydrology Section, he joined AGU in 1917.

Elton V. McCollum, 79, died May 15, 1983. A member of the Geodesy Section, he joined AGU in 1940.

M. M. Newman, 74; a member of the Geomagnetism and Paleomagnetism Section, he had been an AGU member since 1950.

Milton E. Schmidt, 74; a member of the Hydrology Section, joined AGU in 1942.

Books

Nor Any Drop To Drink

William Ashworth, Summit Books, New York, vii + 272 pp., 1982, $17.95 hardbound, $6.95 softbound.

Reviewed by Jay H. Lehr

In *Nor Any Drop To Drink* author William Ashworth displays an exceptional grasp of the hydrologic cycle for one trained as a writer rather than as an earth scientist. Especially remarkable for a popular book is the no-nonsense manner in which he handles popular misconceptions about underground water. Authors of similar books generally mollify readers who hold fallacious, mysterious beliefs concerning groundwater flow. Ashworth gets their attention with the proverbial two-by-four between the eyes by declaring such fallacies to be 100% hogwash. He describes the groundwater system in an exceptionally accurate manner using precise analogies which benefit from his literary skill.

To support his assessment of the nation's water problems, Ashworth draws on a respectable knowledge of population migration and growth and their effects on water supply demand. He is equally talented in balancing environmental concerns with economic needs.

The author is also to be complimented for his clear recognition of the water problems of the state of Arizona. He has done an intensive study of the Central Arizona project and its many weaknesses. He points out that the project will be one of the least-cost-efficient water diversions in national history and advances the opinion that it may never be completed due to the rapidly growing recognition of its deficiencies.

In describing Arizona's problems, Ashworth explains that previously poor water appropriation law is partially to blame for the wanton waste that has marred the history of that state. At the same time he applauds Arizona for at long last writing the most comprehensive water management scheme to reach any state legislature in recent decades. In fact, he holds Tucson, Az., to be the most conservationally aware city in America today. Tucson, he says, has made tremendous strides by changing its habits without altering the overall quality of life as affected by water needs.

Ashworth moves from the prairies of Arizona to the populated east, where he shows equal acumen for the intricacies of the water supply system of New York City, which gathers water from watersheds as far as 240 km away to satisfy the thirst of its citizens. The reader is taught that water diversion is not the program of the west alone. In fact, Ashworth tells us, "The rearrangement of drainage patterns is nearly total: sometimes it seems as though no drop of rain can fall anywhere in the country without being waylaid, bound, gagged, shipped off, and spewed out of a faucet several counties away from its original destination."

Ashworth's prime example of water diversion is the state of California, whose aqueducts twist and wind to feed the incredible overdraft that is the result of the crowded cities and agricultural development of southern California. He quotes Wayne Linn, a California limnologist: "Everytime we have to manipulate the water, it's a monument to man's inability to manage it right in the first place."

But Ashworth recognizes that there will be no way out of this dark tunnel as long as there are so many narrowly oriented water utilities whose sole job is to provide power and water at the lowest possible rate with no consideration for environmental consequences of their actions. And so they continue to talk of diverting the Missouri westward through the farmlands of the Ogallala aquifer. They talk of pipelines from Oregon to Arizona transporting Columbia River water southward to Phoenix. They talk of a pipeline along the Gulf of Texas, running from Louisiana to Mexico and, as it goes, sweeping up water to deposit it into the fertile but dry valley of the Rio Grande. They talk of pipelines in the Adirondacks of New York and of converting Long Island Sound into a freshwater lake. And when they really get wound up, they still talk about the North American Water and Power Alliance (NAWAPA) scheme for picking up the North American continent by the north pole and making all of its northern rivers run backward.

We must still fear this terrible NAWAPA project, especially since Congressman James C. Wright, Jr. (D-Tex.), now more than ever a power in the U.S. House of Representatives, wrote a 1964 book entitled *The Coming Water Famine* in which he supported the folly of NAWAPA. We must never relax our vigil, Ashworth tells us, as there will always be people who are willing to promote such absurdities. It is probable that no author has ever more fully recognized or explained the liabilities of our nation's surface water diversions than William Ashworth.

Ashworth is equally astute when it comes to problems of groundwater overdraft. He offers the reader some well-drawn maps describing the nation's major groundwater resources and indicates the relatively small percentage of our lands that suffer serious overdraft. As with everyone who writes on this subject, however, he focuses the most attention on the famous Ogalala Aquifer whose efforts to gain public sympathy have been astonishingly successful, benefiting people who have practiced water inefficiency at its worst.

Ashworth also clearly analyzes the problems of water desalination and skillfully describes the various ways in which one can turn saltwater into freshwater. In each case he cites the vast amount of energy required to make the rarely practical transition. In sum, I have nothing but the very best to say of Ashworth's accurate, sober, and educational recounting of the status of this nation's water supply and water management failures.

I cannot be as sanguine about his percep-

Books (cont. on p. 550)

Books *(cont. from p. 549)*

tion of its water quality problems. On this subject he follows the lead of many others who place undue emphasis on doom. His overall effort to develop projections for the future of groundwater pollution is perhaps the weakest point of the book; it lacks adequate detail and draws generally unsupportable conclusions. On the subject of acid rain, which he has obviously studied in great detail and describes well, he also chooses to cast excessive gloom. A sentence in point is, "To pollute the rain, therefore, is to commit the ultimate act of pollution. If the rain is dirty, all waters are dirty. As an act of vandalism of the nation's water supply, dumping filth into the rain could not possibly have any peer." This is an overstatement, making acid rain out to be somewhat more the villain than the scientific community is willing to accept.

To his credit, while haranguing U.S. industry for its water pollution crimes, he cleverly puts the lie to the concept that it is our incessant profit motive that creates the problem. He does this by shifting the focus to Russia, supposedly a nonprofit country, which has managed in a few short decades to turn Siberia's mile deep, 300 mile long Lake Baikal into a virtual dead sea.

Ashworth does exhibit a reasonable knowledge of our hazardous waste disposal problems and describes advances that have been made in recent years in legislation and regulation to limit the mistakes of the past. He points out that new regulations that have greatly reduced legal disposal sites may be increasing the dangerous illegal disposal of waste. His review of hazardous waste problems is an acceptable summary for the lay reader though taken largely from anecdotal newspaper accounts. It does not, however, offer the scholarly detail contained in another new book on the subject, *Hazardous Wastes in America*, recently published by the Sierra Club. Ashworth fails considerably in his attempt to tie hazardous waste disposal to well closings and the scary scenario this offers for the future.

Finally, the book is too often fraught with melodrama, which clouds objective, scientific narrative and damages an otherwise excellent text.

The merits of *Nor Any Drop To Drink's* first 200 pages are considerable—usually providing well supported, well presented, and very educational material. Less can be said for the final 50 pages of the text where the author tries to tie together all the information he has presented into a variety of sociological theories. He summarizes the doomsaying aspects of his book poorly in a brief chapter called Losing Control and then follows it with some rather sophomoric instructions to the readers to put plastic jugs in their commodes and aim their lawn sprinklers to hit the grass instead of the sidewalks.

Thus the book ends with a whimper instead of a bang. It is a shame that the author took great pains to educate himself in all aspects of water supply and delivery but did not manage to obtain a grasp of the kinds of water management techniques that could have been articulately described in the book's summary. Still, I strongly recommend the book to readers desiring a brief, reasonably accurate snapshot of the nation's water supply picture as it comes from the camera today.

Jay H. Lehr is executive director of the National Well Water Association, 500 West Wilson Bridge Road, Worthington, OH 43085.

Random Fields: Analysis and Synthesis

E. Vanmarcke, MIT Press, Cambridge, Mass., xiv + 382 pp., $45.

Reviewed by David J. Thomson

Random Fields is a book which I found both technically interesting and a pleasure to read. The problems considered are those of describing multidimensional stochastic data (as opposed to unidimensional, e.g., multivariate, time series data).

The presentation is clear and the book should be useful to almost anyone who uses random processes to solve problems in engineering or science. The author's approach is informal and, while not careless, is not intended for mathematical purists. For example, the index contains six references to limited resolution of measurements but none to measure theory.

The areas covered reflect the author's interest and expertise. I was particularly impressed by the introduction: The emphasis on utility and the importance of local averages is reminiscent of Slepian's classic paper "On Bandwidth" (*Proceedings of the IEEE*, 64, 292–300, 1976); it is also refreshing to read a work on stochastic processes where the author emphasizes that microscopic variations may be of no practical interest to the problem at hand!

Both chapter 2, which provides general background on random fields, and chapter 3, which summarizes second order theory, are well written. Chapter 4, "Spectral Parameters, Level Excursions and Extremes," is an unusually clear and orderly treatment of these topics, although, for example, Rainal's contribution (*Bell System Technical Journal*, 47, 2239–2258, 1968) to this area is not described. Chapters 5–7 cover one-, two-, and multidimensional local average processes. In these the emphasis is again on descriptive statistics such as level crossing rates and extremes parameterized by covariance and spectral functions. A number of interesting constraints imposed on the spectra by the multidimensionality are described; however, the omission of the Paley-Wiener conditions is unfortunate. The section of chapter 8 on parameter estimation is dated and is perhaps the least satisfactory part of the book.

While the chapters present a continuity of thought, the book is well indexed and, for the most part, can be read in sections. The book contains no end-of-chapter problems and so is better suited for study at the postgraduate level than as classroom text. Also, there are no "extended" examples, so those seeking simple solutions to complex problems may be disappointed. There is, on the other hand, much which will guide one toward a useful solution. Compensating for the lack of "extended" examples are many "tiny" examples and continued emphasis on describing the mathematics in physical terms.

David J. Thomson is with Bell Laboratories, Whippany, NJ 07981.

New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Absorption and Scattering of Light by Small Particles, C. F. Bohren and D. R. Huffman, John Wiley, New York, xiii + 530 pp., 1983, $44.95.

Exploration Seismology, vol. 1, *History, Theory, and Data Acquisition*, R. E. Sheriff and L. P. Geldart, Cambridge University Press, New York, xii + 253 pp., 1983, $44.95.

From Rift to Drift: Iowa's Story in Stone, J. C. Troeger, Iowa State University Press, x + 152 pp., 1983, $14.95.

Geodetic Monitoring of Tectonic Deformation: Toward a Strategy, Panel on Crustal Movement Measurements, Committee on Geodesy, Committee on Seismology, Assembly of Mathematical and Physical Sciences, National Research Council, National Academy Press, Washington, D. C., x + 109 pp., 1981.

Introduction to Plasma Theory, D. R. Nicholson, John Wiley, New York, xi + 292 pp., 1983, $29.95.

Polarographic Oxygen Sensors: Aquatic and Physiological Applications, E. Gnaiger and H. Forstner (Eds.), Springer-Verlag, New York, viii + 370 pp., 1983.

Proceedings of the Seventh Symposium on Antarctic Meteorites, vol. 25, *Mem. of Nat. Inst. of Polar Res. Spec. Issue*, T. Nagata (Ed.), National Institute of Polar Research, Tokyo, ix + 343 pp., 1982.

Seafloor Referenced Positioning: Needs and Opportunities, Panel on Ocean Bottom Positioning, Committee on Geodesy, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, National Academy Press, Washington, D.C., viii + 53 pp., 1983.

Short Period Climatic Variations, vols. 1 and 2, J. Namias, University of California, San Diego, California, v + 393 pp., 1982, $13.50.

Weather in Your Life, L. J. Battan, W. H. Freeman, San Francisco, x + 230 pp., 1983, $18.95 (hardbound), $10.95 (paper).

Classified

POSITIONS AVAILABLE

Rensselaer Polytechnic Institute/A Tenure-Track Faculty Position and a Post-Doctoral Research Position. The Department of Geology at Rensselaer Polytechnic Institute is seeking applicants for two openings, a tenure-track faculty position and a postdoctoral research position.

The faculty position available in September 1984 requires a Ph.D. or equivalent degree. The area of specialization within the geosciences is open. Particularly important is the applicant's interest in research and teaching at both the undergraduate and graduate levels (M.S. and Ph.D.) with capability to do creative research in the quantitative sciences. Preference will be given to individuals with research experience beyond the Ph.D.; the level of the appointment is open.

The postdoctoral position is available beginning January 1984 to do research in the field of fission track analysis applied to studies of sedimentary basins. Applicants must be knowledgeable and experienced in fission track analysis.

Our present department is part of a modern, technologically-oriented university, and consists of seven members whose collective expertise encompasses structural geology, geophysics, geochemistry, petrology, glacial and surficial geology, and ecological modeling. The RPI environment provides ample opportunities for field and laboratory experimental research in geology, as well as for interdisciplinary studies in chemistry, physics, biology, mathematics, materials science, engineering and computer science.

A resume and the names of three persons who would be willing to provide letters of reference should be sent to: Donald S. Miller, Chairman, Department of Geology, Rensselaer Polytechnic Institute, Troy, NY 12181.

Rensselaer is an Equal Opportunity/Affirmative Action Employer.

University of Minnesota Stratigrapher/Sedimentary Petrologist. Tenure-track position starting Fall 1984, probably at the Assistant Professor level. The candidate must have a Ph.D. with interest in stratigraphy of sedimentary basins, tectonics and sedimentation, and sedimentary petrology, and will be expected to carry out research and to teach graduate and undergraduate courses in these fields. Please submit resume, academic records, and three letters of recommendation to Dr. Peter J. Hudleston, Department of Geology and Geophysics, 108 Pillsbury Hall, University of Minnesota, Minneapolis, MN 55455 (612)373-3373.

The University is an Equal Opportunity/Affirmative Action Employer.

Postdoctoral Research Associate Positions/Johns Hopkins University. Positions are available for studies of planetary magnetospheres, and for studies of earth magnetosphere and auroral physics, as well as in a newly initiated program in solar physics. Selected candidates will participate in the analysis and interpretation of data obtained from deep space probes (Voyager), or earth orbit, and solar or atmospheric emissions data from earth orbiting spacecraft. Positions are one year, renewable opportunities with flexible starting dates. Contact: Mr. Auli, Department LEA-320E The Johns Hopkins University Applied Physics Laboratory, Johns Hopkins Road, Laurel, Maryland 20707.

An Equal Opportunity Employer M/F.

Faculty Position Available/Massachusetts Institute of Technology. The Department of Earth, Atmospheric, and Planetary Sciences at M.I.T. is seeking to fill a faculty position in seismology. Applicants should preferably have an interest and ability in theoretical seismology, and would be expected to supervise graduate students and teach courses at the undergraduate and graduate level as well as conduct research in that field. Rank is open and depends upon qualifications.

Applicants should send their vitae, list of publications, and a statement of research and teaching interests, no later than 1 November 1983 to:

Prof. W. F. Brace, Chairman
Department of Earth, Atmospheric, and Planetary Sciences
54–918, M.I.T.
Cambridge, MA 02139

M.I.T. is an Equal Opportunity/Affirmative Action Employer.

Professor of Marine Geophysics Tectonics/Stanford University. The Department of Geophysics, Stanford University, is seeking candidates for a tenure track position in the broad area of marine geophysics and tectonics. We seek a creative scientist with experience in gathering, interpreting, and synthesizing marine geophysical data and whose research interests cover depositional, igneous, and tectonic processes on oceanic plates and continental margins. Inquiries are invited from marine geophysicists with demonstrated scientific record in one of the above aspects of marine geophysics or tectonics, who have demonstrated an ability to develop new ideas and research directions, and to guide and teach graduate and undergraduate students. In considering this appointment we are interested in maximizing interactions with ongoing research groups in marine geology, plate tectonics, paleomagnetism, seismology and regional geology at Stanford. The new faculty member will be expected to develop a strong research program involving both government and industrial participation.

Salary and rank will be commensurate with experience and background. Please submit a resume, a brief description of teaching and research interests, and references to:

Dr. Amos Nur
Department of Geophysics
321 Mitchell Building
Stanford University
Stanford, CA 94305

Stanford University is an equal opportunity employer, and encourages the application of qualified women and minorities.

Tenure-Track Faculty Position-Geophysics/New Mexico State University. We are seeking a faculty member whose duties will include teaching both undergraduate and graduate level courses, conducting research and supervising graduate level thesis and dissertation research. We are particularly interested in a seismologist, but persons with experience in other geophysical techniques are invited to apply.

Minimum qualifications include an earned doctorate in geophysics or a closely related area and demonstrated research capability. Teaching experience and demonstrated ability to secure research funding are desirable. The position is available in January 1984 for 9-month academic year. Appointment will be at the rank of Assistant or Associate Professor. Salary and academic rank will be dependent on experience and qualifications.

Applications and names, addresses and telephone numbers of at least three references should be submitted to Dr. Chandler Swanberg, Department of Earth Sciences, P.O. Box 3AB, Las Cruces, NM 88003.

Applications received by October 15, 1983 will be given preference.

New Mexico State University is an Affirmative Action/Equal Opportunity Employer.

Chairman-Department of Geological Sciences/Wright State University. The Department of Geological Sciences invites applications for the position of chairman to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435

Wright State University is an affirmative action/equal opportunity employer. Closing date for the position is October 31, 1983.

Research Associate/Petrography-Petrology. To join a research effort aimed at understanding the condensation history of the solar system by mineralogical, chemical, and isotopic studies of tiny inclusions in primitive meteorites. Applicants must have previous experience in petrology of meteorites and would be a superb petrographer, skilled in the use of the SEM and electron probe. Successful candidate will be dedicated, productive, an effective communicator both orally and in writing, and will have Ph.D. in hand. Vacancy expected to end summer 1983.

Send resume and names of three references to L. Grossman, Department of the Geophysical Sciences, University of Chicago, 5734 S. Ellis Avenue, Chicago, IL 60637.

The University of Chicago is an Equal Opportunity/Affirmative Action Employer.

The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate level, and conduct research leading to scholarly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
Solid-Earth Geophysics
Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applications should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211

GROUNDWATER HYDROLOGIST Opening for a staff or project level groundwater hydrologist to play a lead role in our rapidly expanding geohydrology group. Minimum requirements include a BS or MS degree in Civil/Environmental Engineering or Hydrology with 3–5 years' related experience in groundwater modeling, computer applications and project management. The successful candidate will have demonstrated mathematical simulation skills, hands-on computer modeling and graphic experience, (FORTRAN, USGS codes, etc.) and application of these tools in the assessment of hazardous waste sites and processes. Project responsibilities will require knowledge of current state-of-the-art technology related to groundwater flow and mass transport in saturated/unsaturated porous and fractured media, and the physical, chemical and biological processes associated with these phenomena. Verbal and written communication skills as well as proven experience working with and directing the efforts of multidisciplinary project teams are essential.

GCA Corporation offers a comprehensive benefits package including medical, dental, stock purchase plan and pension plan. Competitive salary commensurate with experience.

Please forward resume to Leonard Aschenbrand. All inquiries will be handled in confidence.

GCA CORPORATION
Technology Division
213 Burlington Road
Bedford, Massachusetts 01730

an equal opportunity employer m/f/h

FACULTY POSITION IN GEOLOGY/ UNIVESITY OF PUGET SOUND Tenure-track Assistant Professor. Field-oriented Geomorphologist with strong interest in Quaternary glacial stratigraphy and landscape processes; to begin February 1, 1984 or September 1, 1984; salary commensurate with experience. The department (3 career faculty) has long established, successful undergraduate program with joint faculty/student research. Team teach Physical Geology—Topics, (all three faculty teach both lecture and labs) and teach a senior level Geomorphology course (lecture and lab) with a process and quantitative focus, including computer applications (Fall). Teach Physical Geology (lecture and lab) and share teaching responsibilities in Historical Geology (Spring). Participate in departmental/University governance, advise students, and continue professional development. Ph.D. in Geology, ability to teach both majors and non-majors, and ability to carry out cooperative, interdisciplinary research with undergraduate geology and other science majors. (Additional info available at Indianapolis GSA meetings). Submit detailed vita, statement of short- and long- term career objectives, transcripts, and names of three references by November 10, 1983, to: Geology Search, University of Puget Sound, P.O. Box 7297, Tacoma, WA 98407. An Equal Opportunity, Affirmative Action Educator/ Employer.

Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

Meteorologist/The City College of The City University of New York. The Department of Earth and Planetary Sciences invites applications for an anticipated opening in meteorology. The appointment will start September, 1984. Applicants should have completed the Ph.D. by the time of appointment and have a strong background in synoptic meteorology and computer applications. In addition, the individual should have an interest in atmospheric chemistry or pollution as applied to urban areas, or physical oceanography. The person hired will be required to teach courses in meteorology, and possibly physical oceanography as well as develop and maintain an active research program. Participation in the C.U.N.Y. Ph.D. Program in Earth and Environmental Sciences is anticipated. Rank and salary will be commensurate with experience. Send resume, transcripts and three letters of reference by November 30, 1983 to Professor Dennis Weiss, Chairman, Department of Earth and Planetary Sciences, the City College, 138 Street and Convent Avenue, New York, N.Y. 10031.

The City College of the City University of New York is an equal opportunity affirmative action employer.

Groundwater Hydrologist/Jordan Gorrill Associates. The Geotechnical and earth science subsidiary of E.C. Jordan Co., Portland, Maine, has an opening for a senior groundwater hydrologist. Candidates should have an advanced degree in hydrogeology or geotechnical engineering and a minimum of seven years of professional experience. Capabilities and experience in field studies and computer modeling of groundwater flow and solute transport is essential. Client contact experience and good writing skills, including report writing experience, are highly desirable. Position will involve work on solid and hazardous waste projects.

Jordan Gorrill Associates is a nationally recognized geotechnical consulting firm providing a wide range of services in geotechnical engineering, geology, hydrogeology, geophysics, and soil science.

Send resume to: Director of Personnel, Jordan Gorrill Associates, subsidiary of E.C. Jordan Co., 562 Congress St./P.O. Box 7050, Portland, ME 04112, (207) 775-2928.

E.C. Jordan Co. is an Equal Opportunity Employer, M/F.

Geophysicist. New Mexico Institute of Mining and Technology invites applications for a tenure track position in explorations seismology at the assistant professor level to begin as soon as possible. The position will be a joint appointment between the College Division and the Research and Development Division. A PhD is required. Send letter of application, resume, brief description of teaching and research interest and names of three references to: Personnel, Brown Hall 17, New Mexico Institute of Mining and Technology, Socorro, NM 87801.

An equal opportunity/affirmative action institution.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

The University of California at Berkeley/Space Sciences Laboratory Senior Fellow Program. Renewable three-year appointments will be awarded to Ph.D. scientists who have demonstrated leadership and creativity in astrophysics or space science. Fellows will receive Principal Investigator status and will be expected to develop their own research groups and participate in educational activities of the academic departments. The level, to be determined at the time of appointment, will be Assistant, Associate, or Full Research Scientist depending upon qualifications.

Vita, bibliography, statement of prospective research program and three letters of reference should be sent by December 1, 1983 to Christopher McKee, Acting Director, Space Sciences Laboratory, University of California, Berkeley, California 94720.

The University is an Affirmative Action/Equal Opportunity Employer.

AGU Congressional Science Fellowship. Individuals who are AGU members and U.S. residents are invited to apply for a 1-year assignment on the staff of a congressional committee or a House or Senate member as an advisor on a wide range of scientific issues affecting public policy questions.

Applicants should have a broad background in science; be articulate, literate, and flexible; and be able to work well with people from diverse professional backgrounds.

A public policy background is not required, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to $28,000 plus travel allowances.

How to apply:

Applicants should submit a letter of intent, a curriculum vitae, and three letters of recommendation. The letter of intent should include a statement of why the fellowship is desired, how you qualify for it, what issues and congressional situations interest you, what role you envision as a congressional science fellow, and what outcome you hope for in relation to career goals. The individuals from whom you request letters of recommendation should discuss your professional competence and other aspects of your background that make you particularly qualified to serve as a Congressional Science Fellow.

Send your application to, Department MP, Congressional Science Fellowship, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Application Deadline: March 31, 1984

Meetings

Announcements

Geological Congress Update

The deadline for declaring an intention to attend the 1984 International Geological Congress (IGC) has been extended to September 30, 1983. The meeting, sponsored by the USSR National Committee for Geology, International Union of Geological Sciences (IUGS), will be held in Moscow, USSR, August 4–14, 1984.

For additional information, contact the Organizing Committee of the 27th IGC, Institute of the Lithosphere, 22, Staromonetny, Moscow, 109180.

Cometary Astronomy

The 1983 American Workshop on Cometary Astronomy will be held October 1, 1983, in Pasadena, Calif. The workshop will include presentations by John Bortle, Charles Morris, Ray Newburn, John Sanford, Zdenek Sekanina, Paul Weissman and others. Tours of the Jet Propulsion Laboratory's Space Flight Operations Facility and sessions in the San Gabriel Mountains on observational techniques are also on the agenda. This second annual workshop is being sponsored by the International Halley Watch and *International Comet Quarterly*.

Attendance is limited to the first 100 registrants. Non-U.S. citizens need security clearances. For more information contact Comet Workshop, Jet Propulsion Laboratory, M/S T-1166W, 4800 Oak Grove Drive, Pasadena, CA 91109.

Rock Mechanics

The 25th U.S. Symposium on Rock Mechanics will be held June 25–27, 1984, in Evanston, Ill. The organizers of the symposium are soliciting papers on the following topics: in situ stress (types and measurement), design analysis, deformation behavior, foundations behavior, fracture (lab and field), site characterization, variations in liner design, design of protective structures, improvements in blasting techniques, waste isolation in repositories design and construction, earthquake source mechanisms, machine-rock interaction, and ground control in mining.

Authors should submit abstracts of up to 1000 words and several figures by November 1, 1983, to C. H. Dowding, Department of Civil Engineering (25), Northwestern University, Evanston, IL 60201 (telephone: 312-492-7270).

Pacific Chemical Congress

The 1984 International Chemical Congress of Pacific Basin Societies (PAC CHEM '84), the first chemical conference ever held for the entire Pacific Basin, will take place December 16–21 in Honolulu, Hawaii. The conference program consists of more than 60 symposia with papers being presented on recent developments in agrochemistry; analytical, clinical, environmental, and health chemistry; applied chemistry; biological and pharmaceutical chemistry; catalysis, colloidal, physical, and surface chemistry; economics and management; geochemistry; inorganic and nuclear chemistry; information transfer and computation; macromolecular chemistry; and organic chemistry. Speakers at the plenary sessions will deal with such topics as energy, food, economic development, population stabilization, and the role of chemistry in enhancing the development of the Pacific Basin.

In order to have a paper considered for presentation at the conference, five copies of a 150-word abstract (with the original on a special PAC CHEM form for reproduction) and one copy of an expanded 500-1000 word abstract must be submitted by June 1, 1984, to PAC CHEM '84, Meetings and Divisional Activities Department, American Chemical Society, 1155 Sixteenth Street, N.W., Washington, DC 20036 (telephone: 202-872-4396) or to PAC CHEM '84, The Chemical Institute of Canada, 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3 (telephone: 613-233-5623) or to PAC CHEM '84, The Chemical Society of Japan, 1-5, Kanda-Surugadai, Chiyoda-ku, Tokyo 101 (telephone: 03-292-6161). Persons in all other countries may contact the International Activities Office of the American Chemical Society for more information (telephone: 202-872-4449; cable: JIECHEM; telex: 892582). The official language of the conference is English.

The Pacific Chemical Congress Subcommittee on Scientific Program Development will referee all contributed papers, and notifications will be sent to authors by July 15, 1984. Contributed papers will be considered for appropriate symposia, for general sessions, and for poster presentations.

The conference is sponsored by the chemical societies of Canada, Japan, and the United States and chemical societies from Asia, Latin America, and 16 other Pacific Basin countries will participate officially in the congress.

Geophysical Year

The complete Geophysical Year last appeared in the August 30, 1983, *Eos*.

New Listings

A boldface meeting title indicates sponsorship or cosponsorship by AGU.

June 25–27, 1984 25th U.S. Symposium on Rock Mechanics, Evanston, Ill. (C. H. Dowding, Dept. of Civil Engineering (25), Northwestern Univ., Evanston, IL 60201; tel.: 312-492-7270.)

Sept. 24–25, 1984 Seminar: Enhanced Biological Removal of Phosphorus from Wastewater, Paris, France. Sponsor, International Association on Water Pollution Research and Control. (Michel Florentz, Phosphorus Seminar, Anjou-Recherche, 52, rue d'Anjou, 75384 Paris Cedex 08, France; tel.: 266-91-50; telex: Geneaux 280 332 F.)

Dec. 16–21, 1984 International Chemical Congress of Pacific Basin Societies, Honolulu, Hawaii. Sponsors, ACS, Chemical Institute of Canada, and Chemical Society of Japan. (PAC CHEM '84, Meetings and Divisional Activities Dept., American Chemical Society, 1155 Sixteenth St., N.W., Washington, DC 20036; tel.: 202-872-4396; PAC CHEM '84, The Chemical Institute of Canada, 151 Slater St., Suite 900, Ottawa, Ontario K1P 5H3; tel.: 613-233-5623; PAC CHEM '84, The Chemical Society of Japan, 1-5, Kanda-Surugadai, Chiyoda-ku, Tokyo 101; tel.: 03-292-6161.)

AGU Fall Meeting: Housing and Registration

The 1983 Fall Meeting of the American Geophysical Union will be held in San Francisco, California, December 5–10 at the Cathedral Hill Hotel and the Holiday Inn Golden Gateway Hotel. San Francisco is a dynamic, exciting city, known to the world for its spectacular scenery, fabulous restaurants, cosmopolitan life style, and gentle climate. It is a superb meeting location at any time of the year.

Registration

Everyone who attends the meeting must register. Preregistration (received by November 10) saves you time and money. The fee will be refunded to you if AGU receives written notice of cancelation by November 28. Registration rates are as follows:

	Preregistration	After Nov. 10
Member	$65	$80
Student member	$32	$37
Retired senior member	$32	$37
Nonmember	$90	$105
Student nonmember	$41.50	$56.50

Registration for 1 day only is available at one half the above rates, either in advance or at the meeting. Members of the American Meteorological Society, the American Society of Photogrammetry, the European Geophysical Union, Union Geofisica Mexicana, and the American Congress on Surveying and Mapping may register at the AGU member rates.

The difference between member (or student member) registration and nonmember registration may be applied to AGU membership dues if a completed membership application is received at AGU by February 10, 1984.

To preregister, fill out the registration form, and return it with your payment to AGU by November 10. Your receipt will be included with your preregistration material at the meeting. Preregistrants should pick up their registration material at the registration desk at the Cathedral Hill Hotel. Hours are 8 A.M. to 4 P.M., Monday through Saturday. On Sunday, December 4, registration hours are 5:30 to 7:30 P.M.

Hotel Accommodations

Blocks of rooms ($47 singles, $53 doubles) are being held at the Cathedral Hill, the Holiday Inn Golden Gateway, the Holiday Inn Civic Center, the San Franciscan, and the Grosvenor Inn for those attending. Read the housing application, and mail the completed application form to the housing bureau early to ensure reservations at your preferred hotel. *Reservation forms must be sent directly to the Housing Coordinator, AGU Fall Meeting, San Francisco Housing Bureau, P.O. Box 5612, San Francisco, CA 94101.* Do not send housing reservation forms to the hotels.

Reservations must be received by November 1 to be confirmed. Do not write or call AGU for room reservations.

Free parking is available only to registered guests of each hotel as indicated.

Scientific Sessions

The program summary will be published in the October 18 *Eos*. The preliminary program along with the abstracts will be published in the November 8 *Eos*. The final program, with presentation times, will be distributed at the meeting. Scientific sessions will be held at the Cathedral Hill and the Holiday Inn Golden Gateway hotels only.

RETURN THIS FORM WITH PAYMENT TO:

Meeting Registration
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

PLEASE PRINT CLEARLY

NAME ON BADGE ____________________

AFFILIATION ____________________

MAILING ADDRESS ____________________

TELEPHONE # ____________________

HOTEL ____________________

Days you plan to attend
Please check the appropriate box(es)

☐ Dec. 5 ☐ Dec. 6 ☐ Dec. 7
☐ Dec. 8 ☐ Dec. 9 ☐ Dec. 10

Members of the cooperating societies may register at AGU member rates

Please check appropriate box

☐ Member AGU ☐ Nonmember

Member cooperating society,

☐ AMS-American Meteorological Society
☐ ASP-American Society of Photogrammetry
☐ ACSM-American Congress on Surveying and Mapping
☐ EGU-European Geophysical Union
☐ UGM-Union Geofisica Mexicana

Nonmembers

The difference between member (or student member) registration and nonmember registration may be applied to AGU dues if a completed membership application is received at AGU by February 10, 1984.

Preregistrants

Your receipt will be in your preregistration packet. The registration fee will be refunded if written notice of cancelation is received in the AGU office by November 28. The program and meeting abstracts will appear in the November 8 issue of *Eos*.

AGU 1983 FALL MEETING
DECEMBER 5-10
San Francisco, California

REGISTRATION FORM

Deadline for Receipt of Preregistration NOVEMBER 10, 1983

(rates applicable only if received by November 10 with payment)

	More than one day	One day
MEMBER	☐ $65	☐ $32.50
STUDENT MEMBER	☐ $32	☐ $16
RETIRED SENIOR MEMBER*	☐ $32	☐ $16
NONMEMBER	☐ $90	☐ $45
STUDENT NONMEMBER	☐ $41.50	☐ $20.75

*65 or over

SECTION LUNCHEONS/DINNER

Circle section and indicate number of tickets. All lunches begin at noon. SPR dinner begins at 6:30 P.M.

____ Planetology/Volcanology, Geochemistry and Petrology, Tuesday, $9
____ Seismology/Tectonophysics, Tuesday, $5
____ Geomagnetism and Paleomagnetism, Wednesday, $5
____ Hydrology, Wednesday, $9
____ Ocean Sciences, Wednesday, $9
____ Solar-Planetary Relationships, Wednesday, $20 (dinner)
____ Atmospheric Sciences, Thursday, $9
____ Geodesy, Thursday, $9

Total Enclosed $ ____________________
(All orders must be accompanied by payment or credit card information. Make check payable to AGU.)

Charge to: ☐ American Express ☐ Visa ☐ Master Card

Card Number ____________________

Master Card Interbank No. ____________________

Expiration Date ____________________

Signature ____________________

Office Use

Code

Check No.

New Special Sessions

See the June 28, July 26, and August 16 issues of *Eos* for listings of other special sessions.

Geodesy (G)

Laser Geodynamics Satellites (LAGEOS) (Session chairman: S. C. Cohen, NASA/GSFC, tel. 301-344-8555)

Crustal Dynamics (Session chairman: Don Trask, JPL, tel. 213-354-4878)

Global Positioning Satellite: Geodetic and Geophysical Applications (Session chairman: M. Ananda, Aerospace Corporation, tel. 213-647-1947)

Interdisciplinary Research in Geodesy and Oceanography (cosponsored with Ocean Sciences (*O*) (Session chairman: C. J. Koblinsky, NASA/GSFC, tel. 301-344-7026)

Session Highlights

See the June 28, July 26, and August 16 issues of *Eos* for descriptions of other special sessions.

Interdisciplinary Research in Geodesy and Oceanography (G & O)

Progress on a variety of interdisciplinary problems in geodesy and oceanography has been achieved recently as a result of the great improvements in satellite positioning. Such problems include: tides; the geopotential and gravity fields; ocean bathymetry; seafloor spreading; ocean circulation; and the effects of the ocean on the rotation of the earth. Invited talks by leaders in the field will summarize current trends and future directions of interdisciplinary work in geodesy and oceanography, as well as describe upcoming satellite missions affecting this research.

There will also be two additional sessions to incorporate timing, earth rotation, tides, and gravity data analysis.

Exhibits

The exhibits will be located on the mezzanine, Cathedral Hill Hotel, Monday through Thursday, December 5–8, 9:30 A.M. to 4:00 P.M.

The following exhibitors are confirmed:

Academic Press, Inc.
American Geophysical Union
Defense Mapping Agency/HTC
EG&G Geometrics
Elsevier Science Publishing Co.
Handar
Jet Propulsion Laboratory
Kinemetrics
Nature's Own
Phoenix Geophysics
Qualimetrics, Inc.–WEATHERtronics
Refraction Technology
Schonstedt Instrument Co.
Sprengnether Instruments
Springer-Verlag, New York
Teledyne Geotech

Meetings (cont. on p. 554)

FIELD TRIP FORM

I wish to attend the Franciscan Nano-terrane field trip on Sunday, December 4. My check for $25 is enclosed.

In case I am not among the first 40:

☐ I wish to be put on the waiting list. (If you don't go, money will be returned on the day of the trip.)

☐ I wish my money returned.

Signature ____________ Print Name ____________

Date ____________________

Address ____________________

Telephone ____________________

Mail form to: M. C. Blake, Jr., Mail Stop 75, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025

HOTEL ACCOMMODATIONS

PARTICIPATING HOTELS

Cathedral Hill Hotel
Van Ness at Geary Street
(800) 227-4730

Holiday Inn Golden Gateway
1500 Van Ness Avenue
(415) 441-4000

Grosvenor Inn
Van Ness and Geary
(415) 673-7411

Holiday Inn Civic Center
50 8th Street
(415) 626-6103

San Franciscan Hotel
1231 Market Street
(415) 626-8000

ROOM RATES FOR ALL HOTELS

Single $47
Double $53
Twin $53

Suites available upon request

PARKING: Cathedral Hill Hotel: free to registered guest
Holiday Inn Golden Gateway: free to registered guest
San Franciscan Hotel: free to registered guest

All hotel reservations must be made on the housing form by November 1, 1983. No telephone requests will be accepted. Confirmations will be mailed directly to registrants by the individual hotels. After confirmation has been received, changes and cancelations should be made directly to the hotel.

Mail your completed form directly to:

Housing Coordinator
AGU Fall Meeting
San Francisco Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

American Geophysical Union
1983 FALL MEETING

HOUSING REGISTRATION FORM

READ CAREFULLY and RETURN FORM DIRECTLY TO THE SAN FRANCISCO HOUSING BUREAU AT THE FOLLOWING ADDRESS:

Housing Coordinator
AGU Fall Meeting
SF Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

Please print or type all information, abbreviating as necessary. Confirmation will be sent by the hotel to the individual named in Part I. If more than one room is required, this form may be photocopied.

Part I

REQUESTOR

Last Name First

Name of Company or Firm

Street Address or P.O. Box Number

City State/Prov. Zip-U.S.A.

Country Telephone Number

Part II

INSTRUCTIONS: Select *THREE* hotels of your choice from the list of participating facilities, then enter the name on the lines below.

First Choice ________ Second Choice ________ Third Choice ________

NOTE: Rooms are assigned on a "First Come, First Served" order, and if none of your choices is available, another facility will be assigned based on a referral system. A cut-off date is in effect; your application may not be processed if received after 14 days prior to your arrival date. **AGU housing registration deadline is November 1.**

Part III

INSTRUCTIONS: 1. Select type of room desired with arrival and departure dates.
2. *PRINT* or *TYPE* names of *ALL* persons occupying room.
3. If more than two persons share a room, check twin and the hotel will assign two double beds.

CHECK ONE		Guest Names (Last name first)
☐ SINGLE (Room with one bed one person)	Arrival Date ________	1. ________
☐ DOUBLE (Room with one bed two persons)	Arrival Time ________ AM/PM	2. ________
☐ TWIN (Room with two beds two persons)	Departure Time ________	3. ________
☐ EXTRA PERSON		4. ________

IMPORTANT NOTE: Hotel MAY require a deposit or some other form of guaranteed arrival. If so, instructions will be on your confirmation form.

Meetings (cont. from p. 553)

Social Events

An icebreaker party on Monday evening at the Cathedral Hill Hotel will be the opening social event of the meeting. There will be an awards ceremony on Thursday evening from 5:45 to 6:30 P.M. in the Crystal Ballroom of the Holiday Inn Golden Gateway. All meeting participants are invited to attend. At a wine-tasting reception following the ceremony you can share a glass of wine with your colleagues.

Complimentary refreshments will be served daily at both hotels 9:30–10:30 A.M. and 2:45–3:45 P.M.

Business Meetings and Section Luncheons/Dinner

The AGU Council will meet Tuesday, December 6, at 5:30 P.M.

The section lunches and dinner will be held at the following restaurants: Nikko, at Van Ness and Pine; Casa de Cristal, 1122 Post Street; A. Sabella's, on Fisherman's Wharf; and the Holiday Inn Golden Gateway.

Planetology/Volcanology, Geochemistry and Petrology

Tuesday, December 6, 12 P.M., Casa de Cristal, $9.

Seismology/Tectonophysics

Tuesday, December 6, 12 P.M., Nikko, $5.

Geomagnetism and Paleomagnetism

Wednesday, December 7, 12 P.M., Casa de Cristal, $5.

Hydrology

Wednesday, December 7, 12 P.M., Holiday Inn Golden Gateway, $9.

Solar-Planetary Relationships

Wednesday, December 7, 6 P.M., A. Sabella's, $20.

Atmospheric Sciences

Thursday, December 8, 12 P.M., Nikko, $9.

Geodesy

Thursday, December 8, 12 P.M., Holiday Inn Golden Gateway, $9.

Field Trip

On Sunday, December 4, 9 A.M. to 5 P.M., in connection with the Nano-Plate-Tectonic Symposium, there will be a field trip to the Franciscan nano-terranes in San Francisco, stressing their contact relations. The trip will be led by Clark Blake and Clyde Wahrhaftig.

The $25 per person cost includes tour bus, lunch, and field trip guide.

The trip will leave from and return to the Cathedral Hill Hotel.

The trip will be limited to 40 persons, and space will be reserved for the first 40 to sign up. Others can be put on a waiting list, or their checks can be returned, as they wish. Those interested should send the form printed in this issue with a check made out to M. C. Blake, Jr., addressed as indicated on the form. Be sure to mark on outside of the envelope "For AGU Dec. Field Trip."

Air Fare Information

Special AGU Discounted Air Fares Available When You Fly UNITED to San Francisco

Your toll-free number for flight reservations: 800-521-4041 (Michigan residents 800-482-0243)

Your AGU Convention Number 4367

Special arrangements have been made with United Airlines to offer you a $10 discount off Super Saver fares with the 7-day minimum stay requirements waived . . . only available when you call the unlisted, toll-free number of United's Convention Desk: 8:30 A.M.–5:30 P.M. EST, Monday–Friday.

Just call the above number, available to those within the 48 contiguous states. Ask for the Convention Desk. Tell them you are attending the AGU convention in San Francisco or give them AGU's convention number: 4367.

Here are the details on your special AGU convention fare:

- $10 discount on the roundtrip Super Saver/coach fare in effect at the time of travel.
- The 7-day minimum stay is NOT required.
- Travel must commence no earlier than December 1, 1983, and must be completed on or before December 12, 1983.
- Reservations should be made as early as possible. The final date for reservations and ticketing is the day before departure. Reservations will be accepted after this date, but at the higher fare.
- Ticket purchase may be made directly from United; they will mail your tickets direct to you. Just provide your form of payment when you call. If you wish to purchase your ticket through an authorized travel agency, you may do so. However, YOU, not your travel agent, should call United's unlisted number.

Special Note

In the current "air fare war" there may be sporadic and short-lived discounted fares from specific cities to San Francisco. These fares have restrictions and are limited. United's convention specialists will assist you in determining if your travel plans meet these specific restrictions.

AGU and United Airlines are working together to bring you a better meeting for less. Use the United Convention Desk; help yourself and AGU at the same time.

AGU

Hydrology Section Actions

The framework of a new financing and publishing plan for *Water Resources Research* (WRR) was announced at the June 2, 1983, Hydrology Section Executive Committee meeting in Baltimore. In July, AGU General Secretary Leslie Meredith set rates based on the plan. The outline of the plan is as follows:

- The journal will begin monthly rather than bimonthly publication in January 1984.
- The member subscription rate will be $47 and the library subscription rate will be $220.
- There will be no page charge on the first 8 typeset pages of any paper.
- There will be a mandatory page charge of $125 on all pages over 8, except for invited review papers, for which there will be no page charges.
- As before, author-prepared copy is unacceptable unless identical to AGU typeset papers.
- Reprints will be available at $10 per page per hundred copies.

The Hydrology Section Executive Committee is further considering how best to meet the growing information needs of the Hydrology Section. Suggestions put forward include splitting WRR and/or developing a new journal. The first action would serve to contain the cost of WRR, which is increasing along with the increasing volume of high-quality material being submitted for publication. This action would carry with it the danger of deepening rather than reducing the differences among members of the section. A new journal would be intended to serve the more practically-oriented members of the section. Such a journal would of course be in direct competition with several existing, non-AGU journals. Is another one needed?

The executive committee would welcome written comments on these ideas.

Certification

A new organization known as the American Institute of Hydrology (AIH) and its associated Board of Registration has apparently come into being without prior consultation by its founders with AGU or with other concerned scientific and engineering societies (*Eos*, April 19, 1983, p. 146). Certification of hydrologists by AIH does not have any legal status: AIH is not backed by state or federal legislation as is common for Professional Engineer (PE) or Professional Geologist (PG) certification.

The Committee considered it questionable that there is a need for further certification routes (over and above PE and PG) for hydrologists; and it considered inappropriate a self-proclaimed certification body that is not aligned with existing scientific and professional societies. The committee agreed that AGU had no direct role to play in the certification or registration of "professional hydrologists" at this time and that the certification procedures available through the traditional registration bodies are currently adequate to satisfy society's needs for protection from unprofessional practice.

Horton Research Grant

The Horton Research Grant for 1983–1984 has been awarded to Jane Stockman, who is at the Department of Civil Engineering at Stanford University. The award, which carries a grant of $4500, was presented to Stockman at the Section luncheon on June 1. Her research topic is on the characterization of the dispersive properties of a heterogeneous, porous medium.

Committee on History

A Hydrology Section Committee on the History and Heritage of Hydrology has been formed, to be chaired by Bill Back; Marshall Jennings, Gerry Meyer, and Ed Landa have also agreed to serve. Bill would like to add three more members who are not with the USGS and whose area of interest is surface water. Anyone interested in this committee should contact Bill Back (703-860-6083) or Allan Freeze (604-228-6462).

The Committee plans to write up its purpose and goals in an article for *Eos* and then to schedule some History of Hydrology sessions, probably for the 1984 Fall and/or 1985 Spring Meetings.

Meetings

The executive committee judged the high point of the hydrology sessions at the AGU 1983 Spring Meeting to be the two-session symposium of Groundwater Flow and Fractured Rocks, which was attended by well over 100 hydrologists. The International Symposium on Urban Hydrology and the two sessions on the Nationwide Urban Runoff Program were also very successful. Thanks are due to Jack Robertson, Charley Faust, Jim Mercer and Jacques Delleur for their roles in organizing these sessions.

John Ritter, hydrology program chairman for the 1984 Spring Meeting in Cincinnati, and Dennis Lettenmaier, hydrology program chairman for the 1983 Fall Meeting in San Francisco, reported that a full slate of sessions is planned for their meetings.

The committee noted that poster session assignments still cause some problems. It is important that the section recognize and maintain the status of poster sessions as being equal to verbal presentations. In many ways poster sessions have an advantage over verbal presentations in that lengthy discussions can result between those who have mutual interests.

Section Committees

The Hydrology Section Committees and their chairmen for 1982–1984 are:

Erosion and Sedimentation Walter F. Megahan, USDA, Forest Service, 316 E. Myrtle St., Boise, ID 83702, 208-334-1457.

Remote Sensing Thomas J. Jackson, USDA Hydrology Lab., Beltsville, MD 20705, 301-344-3490.

Water Quality Kenneth H. Reckhow, School of Forestry and Environmental Studies, Duke Univ., Durham, NC 27706, 919-684-2802.

Ground Water John B. Robertson, USGS, EGS Mail Stop 410, Reston, VA 22092, 703-860-6976.

Precipitation Vijay K. Gupta, Dept. of Civil Engineering, Univ. of Mississippi, University, MS 38677, 601-232-5366.

Surface Runoff Keith Hipel, Dept. of Systems Design Engineering, Univ. of Waterloo, Waterloo, Ontario, Canada N2L 3G1, 519-885-1211, ext. 3113.

Water in the Unsaturated Zone Hubert J. Morel-Seytoux, Director, Engineering Research Center, Colorado State Univ., Fort Collins, CO 80523, 303-491-8549.

Snow and Ice Albert Rango, Hydrology Lab., Rm. 139, Bldg. 007, USDA/ARS/BARC-West, Beltsville, MD 20705.

History and Heritage William Back, USGS, Mail Stop 432, Reston, VA 22092, 703-860-6083.

Editor of *Eos* for Hydrology Mary P. Anderson, Dept. of Geology and Geophysics, Univ. of Wisconsin–Madison, 1215 W. Dayton St., Madison, WI 53706, 608-262-2396.

The activities of the Urban Hydrology Committee have been placed in the Surface Runoff Committee. The executive committee thanks Jacques Delleur and his committee members for their excellent work on the Urban Hydrology Committee and invites them to contact Keith Hipel to continue their activity.

Attending the executive committee meeting were Jared Cohon, Jacques Delleur, Peter Eagleson, Allan Freeze, Mark Houck, Ivan Johnson, Jurate Landwehr, Dennis Lettenmaier, Roy Sidle, Waldo Smith, Fred Spilhaus, Juan Valdes, and Jim Wallis.

Upgrading Teachers

The issue of government legislation to support the upgrading of secondary school science and math educators was the focus of AGU's Education and Human Resources (E & HR) Committee meeting held in Baltimore June 2, 1983, during AGU's 1983 Spring Meeting.

The committee discussed several ways in which AGU could be involved in encouraging teacher upgrading without subjecting other government-supported scientific projects to decreases. Committee Chairman Charles Hollister said he has talked to individuals that he knows on the House and Senate appropriations committees, and after the Senate version has passed he will report back to the E & HR committee. The question will be: Does AGU want to become involved, and if so, how?

On other topics, the following actions were taken.

- The final mockup of the *Careers in Oceanography* booklet was approved. It will be published this fall.
- It was agreed to continue the Job Centers at the national AGU meetings at their current level. They are serving a small number of attendees at almost no cost.
- The committee reviewed and revised a questionnaire for mailing to a select number of AGU members to help the committee evaluate the success of current programs and propose future projects.
- Louise Levien reported on the Spring Meeting special session on Career Choices: The Personal and the Scientific. An account of this session appears in this issue.

Those attending the committee meeting, besides Hollister, were committee members Laurie Brown, Louise Levien, Chris Russell and Connie Sancetta. Also attending was ex-officio member Robert Manka, AGU's representative to the Scientific Manpower Commission.

Comments on educational and human resources programs and questions of concern are welcome and should be addressed to the chairman of this committee at the AGU headquarters address.

Panel Discusses Career Choices

Career Choices: The Personal and the Scientific was the subject of the 1983 AGU Spring Meeting panel discussion sponsored by AGU's Education and Human Resources Committee. Laurie Brown (University of Massachusetts–Amherst) moderated the five-member panel of Aviva Brecher (Arthur D. Little Co.), Robin Brett (USGS), Louise Levien (Exxon Production Research Co.), Chris Russell (UCLA), and Fred Spilhaus (AGU).

In combining personal and scientific concerns into career choices, most panelists agreed on the need to be flexible about what you do, to do something you think you can do well, to keep a sense of humor, and, if possible, to use mentors and the network to help you find and acquire fulfilling positions.

Chris Russell has been at UCLA as a graduate student, on the research faculty, and now on the tenured faculty. He advised one to "be the world's expert in something," but do what you enjoy since you will be spending considerable time doing it. Chris said he used his skill as a writer to gain recognition and his current position. He felt that working in an established group until he became part of the system was a valuable approach. Chris balances his career and home life by making sure housekeepers and babysitters are reliable, which helps both his career and marriage to survive.

Louise Levien went from graduate school to a post-doctoral research position at Caltech. This transition was motivated by purely scientific and career considerations. The move from California to Exxon was considerably different. She had decided not to apply for academic positions because research funding is so difficult for young scientists to obtain, and because she "was not prepared for a 7-year test". In addition, her long-time boyfriend had a job offer in Houston, so she agreed to look there, but only to accept a position she felt was viable on its own merits. Louise feels the positive sides of an industry job include more easily available research funding, fairly regular working hours, and a good salary. The negative sides of industrial positions are very limited vacation, massive changes in research projects, and the real possibility of being laid off.

Fred Spilhaus, partially motivated by patriotism, went from graduate school to the CIA. He turned around one of Chris Russell's comments by saying that "whatever you do, you might as well enjoy it." Fred's father, who was also his mentor, played a large part in his transition from the CIA to AGU. Fred disregarded the first request for an application to be assistant director of AGU. He then learned that the current director was retiring and that this position was created to bring in a new director for the Union. Fred's persistent mentor had a second application sent to him, and this time he applied. Fred stated that society work is very rewarding but strenuous and that he is traveling about 40% of the time.

Aviva Brecher talked in general about balancing scientific and personal goals as well as specifically about her own choices. She described a career-energy diagram in which some positions have high potential energy while others have high kinetic energy. There is always some activation energy associated with a career change, which can either provide a gradual or a drastic change. A learning curve is always associated with a new position, and a question to ask yourself is how steep do you want that curve to be? Aviva changed schools several times because her husband's career was more advanced, and she has worked both in academic and research positions. She emphasized the need for a very valuable skill in her present work at Arthur D. Little Co.: the ability to teach yourself. Given the heavy government funding of her work, Aviva now feels she needs more perspective from the other side and will be spending next year as a Congressional Fellow.

When Robin Brett finished his Ph.D., academic positions in Australia were limited, so he came to the Carnegie Institution of Washington's Geophysical Laboratory. Robin emphasized the part that luck, both good and bad, has played in shaping his career. His early work on ore deposits got him an offer to work on meteorites at NASA. Although he was challenged in his work, he felt Houston was not where he wished to settle. Robin stated that early in one's career the need to be flexible is important, whereas once established, more attention can be paid to personal preferences. He left NASA for USGS headquarters in Reston and from there became earth science director for the National Science Foundation (NSF). His move to NSF was made with the clear understanding that his position at the USGS would be available when his NSF appointment was completed. Robin feels that by applying knowledge from one field to another he has made contributions that allowed him to move to positions in varying fields. With his perspective within NSF he cautioned young scientists not to design their research to follow current funding.

The Education and Human Resources Committee plans to hold another panel discussion at AGU's 1983 Fall Meeting, in San Francisco, on Wednesday, December 7. The subject will be "two career couples," and couples are being sought to act as panelists (whether one or both are geoscientists). If you and your spouse would be willing to participate, please contact Connie Sancetta, Lamont-Doherty Geophysical Observatory, Columbia University, Palisades, NY 10964, telephone 914-359-2900, extension 412.

Membership Applications

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Nadhir Al-Ansari (H), Paul Allen, Patti J. Anderson (H), Harvey Belkin (V), Romeo D. Bojkov (A), Michel G. Bonhomme, Bernard Borcard (GP), Richard Brewer (S), G. Ali Dehghani, Michael P. Dempsey (G), F. Kim Deronald (O), Andrew G. Dickson (O), Eric F. Englerecht (T), Carlos Elmer Ferro (S), Edward P. Fulton (O), Darrell G. Fontane (H), Ryoichi Fujii (SM), Daniel H. Gaehlen (A), Barry Alan Goldstein (V), John Graves (T), Olafur Gudmundsson (S), Avijit Gupta (H), E. Anthony Haas (T), James C. Hare (T), Earl J. Hayter (O), Harold C. Helgeson (V), Roger A. Helvey (A), Kjell Henriksen (SA), Don Henriques (V), Yuzo Ishikawa, Albert Jambon (V), Kunio Kai, Michael D. Krom, Hiroshi Kumagai (SS), Michel B. Larue (T), Alfred G. Lathom (GP), Thorne Lay (S), Ching-Yi C. Liao (S), Heung-Jae Lie (O), Theodore C. Loder (O), Robert F. Middelburg (H), David A. Mustart (V), Hans Peter Nachtnebel (H), Sun Won, Nalini (H), Francisco Navarro-Vila (T), Robert W. Nesbitt (V), Michael S. O'Day (T), David D. Parrish (A), Fausto Pasqualucci (A), Samuel T. Pees (T), George C. Pendleton (O), Shyam Prasad (H), Victor A. Ramos (T), D. Rapp (O), George M. Reeves (H), Donald L. Rice (O), Stephen W. Richardson (T), Jeffrey E. Richey (O), Barbara J. Ryan (H), Karl Schneider (S), Ludolf Schultz (P), Antonio Soares Correia (S), Erwin Soess (O), Paolo Tacconi (H), Minoru Takeo (S), Noriyuki Tanaka (V), William I. Thompson (A), Catherine L. Thornton (G), Ronald W. Tracy (T), Tadahide Ui (V), Nancy R. Vandenberg (G), Karel F. Wakker (G), Jeffrey P. Walker (A), Frank J. Williams (O), Stephen Wippel (S), Lucy R. Wyatt (O), Der Liang Young (H), Paul R. Young (S).

Student Status

Susan Q. Boundy (T), Michael A. Celata (S), Francis H. Chapelle (H), Catherine O. Constable (GP), Hyun-Chae Crim (V), Bernadette L. Gandara (S), H. Damielongue (O), William S. Deslowitz (H), Goran A. Ekstrom (S), Andrew J. Friedland (A), A. James Friedson (P), Andrew J. Gratz (P), Stephen S. Hailas (V), Kenneth M. Hinkel (A), Mohammed Mozammel Hoque (H), Jie Huang (S), Jonathan Istok (H), Christine Kulterman (H), S. M. Kong (S), Gail Sue Peterson (V), Richard P. Rijnbeek (SM), Bill Schneider (T), Thomas Southern (T), Judith Wright-Clark (V), Hing-Wen Yuan (GP).

GAP

Separates

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Aeronomy

[illegible]

Electromagnetics

[illegible]

0703 Electromagnetics (Antennas)
IMPEDANCE OF A PLANE CAPACITOR IMMERSED IN A [illegible] AND IN A STREAMING PLASMA

[illegible]

Geochemistry

1820 Chemistry of bodies of water

[illegible]

Geodesy and Gravity

1905 Artificial Satellite Techniques
DIRECT DETERMINATION OF GRAVITATIONAL HARMONICS FROM LOW-LOW GRAVSAT DATA

[illegible]

1940 Polar motion

[illegible]

Geomagnetism and Paleomagnetism

2560 Five variations, paleomagnetism
PALEOMAGNETISM OF THE LATE CRETACEOUS-EARLY TERTIARY NORTH-CENTRAL MONTANA ALKALIC PROVINCE
J.F. Diehl (Dept. of Geol. & Geol. Engrg., Michigan Tech. Univ., Houghton, MI 49931), M.E. Beck, Jr., D. Beske-Diehl, H. Jacobson, and B.C. Hearn, Jr.

2590 Miscellaneous (Detrital remanent magnetism)
PALEOMAGNETISM OF TWO LATE PLEISTOCENE LAKE BASINS IN COLORADO: AN EVALUATION OF DRM AS A RECORDER OF THE GEOMAGNETIC FIELD
J. G. Rosenbaum (U. S. Geological Survey, Denver, Colorado, 80225) and R. L. Reynolds

Hydrology

3110 Erosion and Sedimentation
SUPPLY-BASED MODELS OF SUSPENDED SEDIMENT TRANSPORT IN STREAMS
J. VanSickle and R. L. Beschta (Department of Forest Engineering, Oregon State University, Corvallis, Oregon, 97331)

3110 Erosion and sedimentation
PARTICULATE DYNAMICS, DISSOLVED AND TOTAL LOAD, IN TWO SMALL BASINS, NORTHERN ENGLAND
P. A. Carling (Freshwater Biological Association, The Ferry House, Far Sawrey, Ambleside, Cumbria, UK)

3130 Groundwater
EXPERIMENTAL INVESTIGATIONS OF UNCONFINED AQUIFER POLLUTION FROM RECHARGE BASINS

3130 Groundwater
REGIONAL MANAGEMENT OF AN AQUIFER FOR MINING UNDER FUZZY ENVIRONMENTAL OBJECTIVES
I. Bogardi, A. Bardossy (TISZADATA Consulting Engineers, Budapest, Hungary) and L. Duckstein

3130 Groundwater
S. K. Gupta (Physical Research Laboratory, Ahmedabad 380009, India)

3130 Hydrology (Groundwater)
STEADY-STATE FLUID RESPONSES IN FRACTURED ROCK: A BOUNDARY ELEMENT SOLUTION FOR A COUPLED, DISCRETE FRACTURE-CONTINUUM MODEL
A. M. Shapiro (Technion - Israel Institute of Technology, Faculty of Civil Engineering, Water Resources Division, Technion City, Haifa 32000, Israel), and James Andersson

3140 Limnology (Acidic Precipitation)
SENSITIVITY OF FLORIDA LAKES TO ACIDIC PRECIPITATION
D.E. Canfield, Jr. (School of Forest Resources and Conservation, University of Florida, Gainesville, Florida 32611)

... and recent fisheries data, however, suggest Florida lakes may not be as biologically sensitive as the alkalinity and calcite saturation indices might suggest. Low phosphorus and nitrogen concentrations are primarily responsible for reduced animal and plant populations in acidic Florida lakes. Consequently, predictions of future impacts or trends based on current sensitivity indices should be regarded with caution. (Acidic precipitation, eutrophication, alkalinity, pH).
Water Resour. Res., Paper 3W0457

3160 Runoff and streamflow
IMPROVED PARAMETER INFERENCE IN CATCHMENT MODELS, PART 2: COMBINING DIFFERENT KINDS OF HYDROLOGIC DATA AND TESTING THEIR COMPATIBILITY
George Kuczera (Water Supply Division, Melbourne and Metropolitan Board of Works, Box 4342, Melbourne, Victoria, 3001, Australia)
Often some of the parameters of catchment models fitted to runoff data are poorly-determined thereby making the task of developing useful regionalization relationships more difficult. The Bayesian methodology developed in Part 1 is extended to utilize several kinds of hydrologic data in parameter inference, the goal being to improve the precision of poorly-determined parameters. The concept of compatibility is developed using statistical hypothesis tests. Different kinds of data are said to be compatible if differences between their fitted parameters are not statistically significant. The pooling of incompatible data may undermine the model's ability to predict runoff and also induce bias in the parameters. A hierarchy of three levels of information is introduced to enable systematic checking for compatibility. Finally a case study is presented. Using data on runoff, soil moisture and interception it is shown that substantial reductions in parameter uncertainty can be realized; also the importance of compatibility testing is demonstrated.
Water Resour. Res., Paper 3W1117

3160 Runoff and Streamflow
ANALYSIS OF ALTERNATIVE FLOOD DAMAGE REDUCTION MEASURES ON SMALL RURAL WATERSHEDS USING MULTIPLE RETURN PERIOD FLOODS
D.C. Coulter (Department of Civil Engineering, University of Manitoba, Winnipeg, Manitoba, R3T 2N2) and D.H. Morgan
A heuristic technique for the analysis of alternative flood damage reduction measures on small rural watersheds is presented. The technique is based on dynamic programming. The watershed is divided into a series of sequential reaches or stages. The tradeoffs between storage of floodwaters on marginal upstream land parcels and the reduction in crop damages downstream are evaluated. Allocation of flood resistant crops to the frequently flooded storage areas is considered. The duration of flooding is incorporated into the flood damage functions. The use of cumulative storage volume as the state variable permits the explicit evaluation of expected annual flood damage costs through the consideration of multiple return period floods. The use of cumulative storage volume as the state variable implies that the hydrograph shape at any stage is independent of the spatial distribution of the storage upstream of that stage. Since this condition cannot be guaranteed this technique must be classed as heuristic. The procedure is demonstrated by application to the Wilson Creek Watershed in Manitoba, Canada.
Water Resour. Res., Paper 3W1238

3160 Runoff and Streamflow
A BAYESIAN SURROGATE FOR REGIONAL SKEW IN FLOOD FREQUENCY ANALYSIS
George Kuczera (Water Supply Division, 10th Floor, MMBW, Box 4342, Melbourne, 3001, Australia)
The problem of how to best utilize site and regional flood data to infer the shape parameter of a flood distribution is considered. One approach to this problem is given in Bulletin 17B of the U.S. Water Resources Council for the log-Pearson distribution. Here a lesser known distribution is considered - namely, the power normal which fits flood data as well as the log-Pearson and has a shape parameter denoted by λ derived from a Box-Cox power transformation. The problem of regionalizing λ is considered from an Empirical Bayes' perspective where site and regional flood data are used to infer λ. The distortive effects of spatial correlation and heterogeneity of site sampling variance among sites are explicitly studied with spatial correlation being found to be of secondary importance. The end product of this analysis is the posterior distribution of the power normal parameter expressing, in probabilistic terms what is known about the parameters given site flood data and regional information on λ. This distribution can be used to provide the designer with several types of information. The posterior distribution of the T-year flood is derived. The effect of nonlinearity in λ on inference is illustrated. Because uncertainty in λ is explicitly allowed for, the overstatement in confidence limits due to fixing λ (analogous to fixing log skew) is avoided. Finally, it is shown how to obtain the marginal flood distribution which can be used to select a design flood with specified exceedance probability.
Water Resour. Res., Paper 3W0456

3160 Runoff and streamflow
IMPROVED PARAMETER INFERENCE IN CATCHMENT MODELS, PART 1: EVALUATING PARAMETER UNCERTAINTY
George Kuczera (Water Supply Division, Melbourne and Metropolitan Board of Works, Box 4342, Melbourne, Victoria, 3001, Australia)
A Bayesian methodology is developed to evaluate parameter uncertainty in catchment models fitted to a hydrologic response such as runoff, the goal being to improve the chance of successful regionalization. The catchment model is posed as a nonlinear regression model with stochastic errors possibly being both autocorrelated and heteroscedastic. The end result of this methodology, which may use Box-Cox power transformations and ARMA error models, is the posterior distribution which summarizes what is known about the catchment model parameters. This can be simplified to a multivariate normal provided a linearization in parameter space is acceptable - means of checking and improving this assumption are discussed. The posterior standard deviations give a direct measure of parameter uncertainty and study of the posterior correlation matrix can indicate what kinds of data are required to improve the precision of poorly-determined parameters. Finally, a case study involving a 6-parameter catchment model fitted to monthly runoff and soil moisture data is presented. It is shown that use of ordinary least squares when its underlying error assumptions are violated gives an erroneous description of parameter uncertainty.
Water Resour. Res., Paper 3W1118

3170 Snow and Ice
PORTRAIT OF AN ANTARCTIC OUTLET GLACIER
Siegfried Meier (Technische Universität Dresden, Mommsenstr. 13, GDR)
The Hays Glacier of Enderby Land is a small Antarctic outlet glacier with a "sack-shape" source region of as yet not exactly known southward extent and area (approximately 10^4 km^2). It has a uniform or slightly wavy longitudinal profile, an approximately 7 km wide calving front between 46°15' and 46°20'E, and a partly floating glacier tongue, extending to the seasonally changing front (classification 424 118 according to UNESCO-IAHS, 1970). The longitudinal mean surface slopes are 5-8 m km^{-1} on the tongue, 20-30 m km^{-1} in the step-shaped central section, and 8-14 m km^{-1} in the entrance region. The glacier is bordered to 15 km south of the front by about 500-m-wide serac belts, associated in some places with pressure ridges. It is distinctly separated from the continental ice sheet by three rock walls on the western edge. On the western edge the glacier has a secondary source region of 40 km^2 area which is crevassed and forms a well-defined tributary into the left part of the glacier tongue. The average flow direction of the glacier is north, changing to north-northwest at the front. The outflow velocity is of the order of 1000 m a^{-1}, and the annual iceberg production in Spooner Bay (the southwestern section of Alasheev Bay in the Cosmonaut Sea) is approximately 3 km^3. The dynamic conditions along the glacier are derived from geodetic, strain, and accumulation measurements, and using a modelled internal temperature distribution. (Glacier, portrait, Antarctic)
Hydrological Sciences J. vol. 28, no. 3.

3175 Soil moisture
MOVEMENT OF FINE GRAINS IN THE VICINITY OF WELL SCREENS
György Kovács and László Ujfaludi (Research Centre for Water Resources Development (VITUKI), PO Box 27, H-1453 Budapest, Hungary)
A great number of laboratory experiments have been performed to study the flow generated suffosion process in soil samples supported by perforated screens. Both parallel and radial flow were tested as typical example of the latter is a well-screen supporting the material of an aquifer. The soil samples tested were theoretically divided into two parts: a coarse grained fraction which behaves as a self-supporting skeleton, and a fine-grained fraction filling the pores of the skeleton. Experimental results showed that the process of soil suffosion occurs with increasing flow velocity. At low velocities the fine grains maintain their original position and the flow can be described by Darcy's law. Reaching a critical velocity v_{cr}^{I} the fine grains start to move, partially plugging the pores of the skeleton, while resistance of the sample is increasing. Reaching a second critical flow velocity v_{cr}^{II} results in the development of microchannels, through which fine grains may move out from the layer. The quantity of these fine grains depends on the composition of the soil sample, the flow rate and the slot-diameter of the well-screen. On the basis of the experimental results empirical formulae have been developed for calculating the critical velocities v_{cr}^{I} and v_{cr}^{II}, and the optimum slot sizes of the screen. (Suffosion, well-screen, flow, fine grains)
Hydrological Sciences J. vol. 28, no. 3.

3175 Soil moisture
RAINWATER INFILTRATION INTO A BARE LOAMY SOIL
R. D. Sharma (ICAR Research Complex for NEH Region, Shillong 793003, India)
In order to design micro-catchment water harvesting systems in the Indian desert, rainwater infiltration experiments were conducted on a representative loamy sand soil for a period of six years. Plots with three slopes - 0.5, 5 and 10%, and five slope lengths - 3.12, 7.8, 5.5, 10.75 and 15.5 m were used. With dry antecedent soil conditions, infiltration is governed by rainfall depth, whereas with wet antecedent soil conditions, rainfall impact (intensity) which forms a crust over the soil surface, is the deciding factor. Infiltration decreases significantly with increasing slope due to reduction in the time available for rainfall to infiltrate, but slope length has no significant effect. A graphical multiple curvilinear model to predict rainfall infiltration using rainfall and basin characteristics is developed and the goodness of fit is tested. (Rainwater, infiltration, basin characteristics, India)
Hydrological Sciences J. vol. 28, no. 3.

3175 Soil Moisture
ESTIMATING SPATIAL VARIABILITY IN SOIL MOISTURE WITH A SIMPLIFIED DYNAMIC MODEL
R.B. Clapp (Department of Civil Engineering, University of Maryland, College Park, Maryland 20742), G.M. Hornberger and B.J. Cosby
Observed spatial variability of soil moisture in the field may be due to several factors. Topographic effects, soil heterogeneity, and spatial variability in precipitation and vegetation may induce variability in measured soil moisture. Scaling theory has been suggested as a promising tool for describing soil heterogeneity and, consequently, a portion of spatial variability of measured soil moisture.
We investigate the appropriateness of ascribing soil moisture variability to heterogeneity of soil properties through the use of a model of soil moisture dynamics and scaling theory. The model, termed a wetting-front model, is a simplified representation of water movement in soils. The model conceptually depicts the moisture profile as discrete blocks of soil moisture separated by sharp fronts.
Probabilistic simulations were run with input data appropriate to watersheds R-5 and R-7 at Chickasha, Oklahoma. Results from the simulations indicate that variability due to soil heterogeneity remains relatively constant through time with only slight increases during redistribution following infiltration. Comparison of simulated and observed soil moisture integrated from the surface to the 15-cm depth shows that heterogeneity in soil hydraulic properties may account for approximately 75% of observed standard deviation. (Soil water, spatial variability, scale theory, simulation.)
Water Resour. Res., Paper 3W0184

3180 Water quality
THE REGIONAL EFFECTS OF THE EFFLUENTS FROM THE MISHRAQ SULPHUR MINES IN IRAQ ON THE HYDROLOGICAL SYSTEM
Fadhil R. Al-Dabbagh and Haha A. S. Al-Dabbagh (University of Mosul, Mosul, Iraq)
Sulphur is mined at Mishraq near Mosul, Iraq, by the injection of superheated water. The production area is adjacent to and in contact with the River Tigris. With time an increasing number of hot sulphur springs have erupted in and near the river. Geological and hydrological studies have shown that faults, fractures and cavities in the predominantly limestone rocks increase the hydraulic conductivity and seepage coefficient. The most effective method of controlling the large-scale flow of sulphur into the river was by pumping a barrier of cold water into observation wells bored into areas of high hydraulic conductivity, in order to solidify the sulphur. (Tigris, sulphur, pollution)
Hydrological Sciences J. vol. 28, no. 2.

3180 Hydrology (Water Quality)
CONTROL OF DO LEVEL IN A RIVER UNDER UNCERTAINTY
R.C. Spear (Department of Biomedical and Environmental Health Sciences, University of California, Berkeley, California 94720), G.M. Hornberger
A previously developed regionalized sensitivity analysis for exposing critical uncertainties in models of environmental systems is extended to study control of systems for which there is a good deal of uncertainty in the mathematical model used to describe the appropriate physical, chemical and biological processes. The method is based on a binary classification of Monte-Carlo simulation results as being either satisfactory or unsatisfactory in terms of controller performance. Contrasts in parameters associated with the two classes are elucidated by statistical analysis. This allows the selection of a set of control parameters that maximizes the probability of acceptable behavior in the presence of uncertainty in process parameters. The method is applied to the problem of regulating the discharge from a lagoon with the object of preventing DO from falling below a predetermined standard. It was found that for this system the desired behavior of the controlled process can be achieved with a probability of 0.84 with a particularly simple controller design. Moreover, the results suggest that even modest levels of uncertainty in the process parameters can have a considerable effect on the controller performance and that additional attention should be devoted to the design of robust controllers for environmental systems. (Dissolved oxygen, control, sensitivity analysis).
Water Resour. Res., Paper 3W1224

3180 Water quality
WATER QUALITY MANAGEMENT WITH TIME VARYING RIVER FLOW AND DISCHARGER CONTROL
J.P. Derbay, Y. Smeers (Center for Operations Research and Econometrics, Université Catholique de Louvain, B-1348 Louvain-la-Neuve, Belgium) and D. Fytoca.
An extension of the classical river quality management problem is presented that allows for time varying operation of the treatment plants. The hydrology of the river is represented by a set of steady-state flow regimes; a river water quality model is used for each of these regimes to give a constraint set to be imposed on the discharges, in order to achieve the stream standards during that regime. The objective function distinguishes between investment costs, fixed operating costs, and variable operating costs. A treatment system is sought that minimizes the sum of these costs, taking account of the possibility of operating the treatment system at various different levels during the year. The model is quantified and tested on an example. (Water quality, management, time varying control, river quality).
Water Resour. Res., Paper 3W1386

3180 Water Quality
EVALUATION OF IRRIGATION WATER QUALITY FOR A SPATIALLY VARIABLE FIELD
Eshel Bresler (U.S. Salinity Laboratory, Riverside, California 92501), D. Yaron, and A. Segev
A model to predict the optimal salt concentration of irrigation water when various sources of water are available is described. The model employs a stochastic model for soil water and solute movement and a linear programming economic model for best solutions over an extended time period. Soil water flow generated by irrigation or rainfall is assumed to be steady and vertical. Transient solute transport is assumed to ...

Meteorology

Mineralogy, Petrology, and Crystal Chemistry

4260 Petrogenesis
MID-TO LATE-STAGE KIMBERLITIC MELT EVOLUTION: PHLOGOPITES AND OXIDES FROM THE FAYETTE COUNTY KIMBERLITE, PENNSYLVANIA
Robert H. HUNTER, Randall D. KISSLING, and Lawrence A. TAYLOR (Dept. of Geol. Sci., Univ. of Tennessee, Knoxville, TN 37996)

4260 Petrogenesis
MAGMA-MIXING IN THE LOW VELOCITY ZONE: KIMBERLITIC MEGACRYSTS FROM FAYETTE COUNTY, PENNSYLVANIA
Robert H. HUNTER and Lawrence A. TAYLOR

Oceanography

fixed locations, however, has made significant contributions to our knowledge of the mesoscale variability of the ocean. The mesoscale energies of the sea surface height and geostrophic current have been mapped on a global basis. Their distributions in wave number space have also been analyzed. Because of many of the deficiencies of existing altimeter data (short duration, inadequate orbit, poor accuracy, etc.) most of these results describe only a small portion of the frequency-wave number spectrum of the variability, but they have nonetheless demonstrated the great value of an optimally designed altimetric mission in advancing our knowledge of the global mesoscale variability. The current technology allows satellite altimetry to determine oceanic variability at periods from a few days to 3–5 years, wavelengths from 50 to 10,000 km. Determining the time-averaged general ocean circulation from altimetry is more problematic because an accurate geoid is indispensable. The currently available global geoid models have useful accuracies only at wavelengths greater than about 7,000 km. There have been several attempts at mapping the global ocean circulation at these scales using existing altimeter data and geoids. When these results are compared with hydrographic surveys, some qualitative agreement can be observed, but the quantitative differences are mostly inconclusive due to the geoid and orbit errors. It has been suggested, however, that an altimetric mission that is optimally designed with the current technology, when complemented by a state-of-the-art gravimetric mission to map the earth's gravity field, is able to determine the ocean circulation quantitatively at scales from the ocean basin to about 200 km. (General ocean circulation, mesoscale variability, satellite altimetry, geoid).

Rev. Geophys. Space Phys., Paper 3R1421

4113 Circulation
THERMOHALINE CIRCULATION BELOW THE ROSS ICE SHELF: A CONSEQUENCE OF TIDALLY INDUCED VERTICAL MIXING AND BASAL MELTING
Douglas R. MacAyeal (Department of Geophysical Sciences, University of Chicago, Chicago, IL 60637)
The warmest water below parts of the Ross Ice Shelf resides in the lowest portion of the water column because of its high salinity. Vertical mixing caused by tidal stirring can thus induce ablation by lifting the warm but dense water into contact with the ice shelf. A numerical tidal simulation indicates that vertically well-mixed conditions predominate in the ...

Particles and Fields—Interplanetary Space

Particles and Fields—Ionosphere

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Physical Properties of Rocks

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